N6885827



# PHOTOGRAPHIC SUBSYSTEM REFERENCE HANDBOOK

for the

LUNAR ORBITER PROGRAM

Prepared For

THE BOEING COMPANY
Seattle, Washington

Prepared By

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Approved by:



Date: 15 March 1966

Distribution of this report is prepared in the interest of information exchange. Responsibility for the contents resides in the author or organization that prepared it.

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April 19, 1967

L-C25153-KU

LOP Engineering Note

To: Distribution

From: B. A. Wittman

Subject: Revisions to Photographic Subsystem Reference Handbook, L-018375-RU

Minor revisions to PS hardware since the publication of the PS Reference Handbook require certain minor modifications to the content of this handbook. The data presented in this note should be incorporated by holders of the presently issued document. It is left to the discretion of the user to modify his copy of the handbook in the most convenient manner. This Engineering Note contains both deletions and revisions required to make the document consistent with present hardware design.

PS Reference Handbook Modifications

Page 2-42 - paragraph 2 - last sentence. Change to the following:

"In the reverse film direction, SLE, CLE, RLE and other CCP logic controls the film supply motor"

Page 2-42 - last paragraph. Delete the first two sentences. "Supply looper full (SLF) - - - - - - - - - - terminate the reverse operation". Replace the sentences with the following - "In the reverse direction the film advance motor is normally on if the supply motor is on and the supply looper is electrically empty. If the supply looper contents increase to greater than electrically empty or a logic condition is created which terminates supply motor operation, film advance motor operation will cease."

Page 2-43 - first sentence. Delete the sentence "At the end of . . . . . . until CLE and RLE are reached". Replace the sentence with the following - "At the end of each readout operation (during final readout) the advance motor operates to move film through the camera at a rate equivalent to the take-up rate of the supply spool until CLE and RLE are achieved or until some other logic condition terminates supply motor operation."

Page 2-44 - first sentence, delete the sentence "It will also . . . . . readout operation". Replace the sentence with the following - "It will also turn the take-up drive OFF in the wind forward mode (after Bimat clear) and terminate reverse supply motor operation after each complete readout operation".

Page 2-44 - Paragraph 2.2.4.1.7, second line. Delete the fourth word "dryer".

Page 2-45 - second paragraph. Last two sentences. Delete the last two sentences, as follows: "RLE is also . . . . . . . PS final readout-out mode". Replace the sentences with the following: "RLE is also a condition for turning the take-up drive OFF in the PS wind forward mode and is a condition for turning the supply motor OFF in the final readout mode. RFL will terminate the quick look readout mode and will inhibit takeup motor reverse operation in the PS final readout mode".

Page 2-47 - Figure 2-14 - After the title in the diagram "Index cam" - Add the word "schematic" in parenthesis.

Page 2-50 - paragraph 2.2.4.2 (d), line 10 - change to: "(d) Wind up on takeup spool after final readout (wind forward mode)"

Page 2-50 - paragraph 2.2.4.2 (b), line 14. Change to: "b) Wind up on supply spool after final readout".

Page 2-52 - Paragraph d - Title. Change title to "Unwind from the takeup spool for quick look and final readout".

Page 2-52 - first paragraph, 3rd, and 4th sentences: Delete the sentences as follows: "When the . . . . . inch-per-minute."

Replace the sentences with the following: "When the readout electronics ON command (SPC-3) is given, the takeup motor fills the takeup looper if the take up looper memory indicates that the last condition of the looper was empty. The readout drive pulls film out of the take up looper at approximately 0.27 inches per minute".

Page 2-52 - paragraph d). Add the following paragraph to the subsection d) as follows: "In final readout the film handling system unwinds film from the takeup spool in the same manner as above. However, if the 4-frame capacity of the readout looper is reached, the electrically full signal inhibits any further takeup reverse drive operation but does not turn the readout OFF".

Page 2-52 and 2-53 - paragraph e - Delete subsection e and replace with the following. "e) Windup on Supply Spool after final readout. During this mode of operation, film is transported from the readout looper to the supply spool. When the readout electronics goes off the film that has been readout and stored in the readout looper is pulled out of the readout looper, through the free wheeling processor/dryer and through the normally empty camera storage looper by the supply spool motor. The camera film advance drive is enabled in the reverse direction to assist the supply motor in overcoming the tension losses through the system. The torque of the film advance drive is reduced in the reverse direction by a dropping resistor in series with the armature. Because of the reduced motor torque and the logic associated with the supply looper, film is moved by the film advance at a rate equal to the supply spool takeup rate. The rate of film movement through the film advance mechanism will equal the average rate of the supply takeup.

The supply motor drive and the camera film advance motor drive are controlled in the following manner:

1) The supply motor is ON if the camera storage looper and the readout looper are NOT electrical empty.

2) The camera film advance motor is ON when the supply motor is ON and the supply looper is less than electrical empty.

When both the camera storage and readout loopers are empty, the supply motor is turned OFF which in turn, sheets the camera film advance motor OFF."

Page 2-53 - paragraph f, fifth sentence. Delete the sentence: "This command . . . . . . . . camera advance drive." Replace the sentence with the following: "This command releases the readout drive clutch (sets the readout release memory) and supply motor drive clutch and turns on the camera-advance drive in the forward direction."

Page 2-112 - second paragraph, last two sentences: Delete the sentences as follows: "If the readout . . . . . . . . . . . these loopers are empty". Replace the sentences with the following: "When the readout is turned OFF, film is pulled from the readout looper and wound on the supply spool by the supply spool drive motor and the reverse camera film advance drive motor until both the readout and camera storage loopers are empty".

Page 2-114 - first paragraph, last two sentences. Delete the sentences as follows: "Film is run . . . . . . are both empty." Replace the sentences with the following: "The advance motor is on when the supply motor is on and the supply looper is electrical empty. The supply motor is on if the camera storage and readout loopers are not electrically empty. This film movement continues until the camera storage and readout loopers are empty.

Pages 2-134 through 2-142, section 2.4 - delete section 2.4. The information presented in section 2.4 has been modified and the modifications are covered in the enclosures to Kodak letter L-025140-OU, dated 4/11/67, subject: "Additional Material for PS Fault Isolation Procedures at SFOF".

Page 2-130 - first paragraph, second sentence. Delete the sentence as follows: "Through the logic . . . . . . . . . . . forward direction."

Page 2-152 - paragraph 2.5.2.1.1 - add item M as follows: "m) Camera forward memory off $\overline{CAS\text{-}1}$."

Page 2-153 - paragraph 2.5.2.1.1: Change equation to the following:

$$BME = \left[ (RLF \cdot \overline{TS\text{-}6} \cdot \overline{BMC} \cdot \overline{BCO} + PPS + RTC\text{-}16) * RTC\text{-}5 \right] \cdot \overline{CLE} \cdot$$

$$\overline{TS\text{-}2} \cdot \overline{TS\text{-}4} \cdot \overline{TS\text{-}6} \cdot \overline{BMC \cdot BCO} \cdot \overline{CAS\text{-}4}$$

Page 2-163, paragraph 2.5.2.2.7 - Delete paragraph 2.5.2.2.7: Add new paragraph as follows: "2.5.2.2.7 - Camera Motor Reverse (CAS-7) (Sheet 2)
CAS-7 = CAS-13 . SLE

The camera motor reverse signal is available if the supply motor is ON (CAS-13) and if the supply looper empty signal (SLE) is present. The

presence of this signal enables the camera motor ON signal CAS-5.

Page 2-165 - paragraph 2.5.2.2.1.2 - Delete paragraph 2.5.2.2.12 - Add a new paragraph 2.5.2.2.12 as follows: "2.5.2.2.12 - Supply Motor ON (Reverse Only) (CAS-13) (Sheet 2) -

$$CAS\text{-}13\ \overline{TS\text{-}2}\ .\ \overline{TS\text{-}6}\ .\ \overline{TS\text{-}5}\ (\overline{CLE} + \overline{RLE})\ .\ BMC$$

The supply motor on signal is enabled only if all of the following conditions are in effect:

| | | |
|---|---|---|
| 1) | The solar eclipse memory is not ON | $\overline{TS\text{-}2}$ |
| 2) | The readout enable signal is on ON | $\overline{TS\text{-}6}$ |
| 3) | The wind forward memory is not on | $\overline{TS\text{-}5}$ |
| 4) | The Bimat is clear | BMC |
| 5) | Either the camera or readout storage loopers are not empty | $\overline{CLE} + \overline{RLE}$ |

The presence of this signal disengages the supply brake.

Page 2-171 - Logic diagram sheet 2 - Delete sheet 2 of the CCP logic diagram. Replace the logic diagram, sheet 2, with the attached revised logic diagram.

The PS Reference Handbook was reviewed to correct the areas associated with design revisions since the date of issue of the handbook. In general other minor errors such as typographical errors were overlooked if they did not have any effect on the operational understanding of the PS. This note contains all corrections required as a result of hardware modifications and a second note will not be required as mentioned in discussions with operations personnel and implied in the statement of work for corrections to the PS Reference Handbook.

Bernard A. Wittman

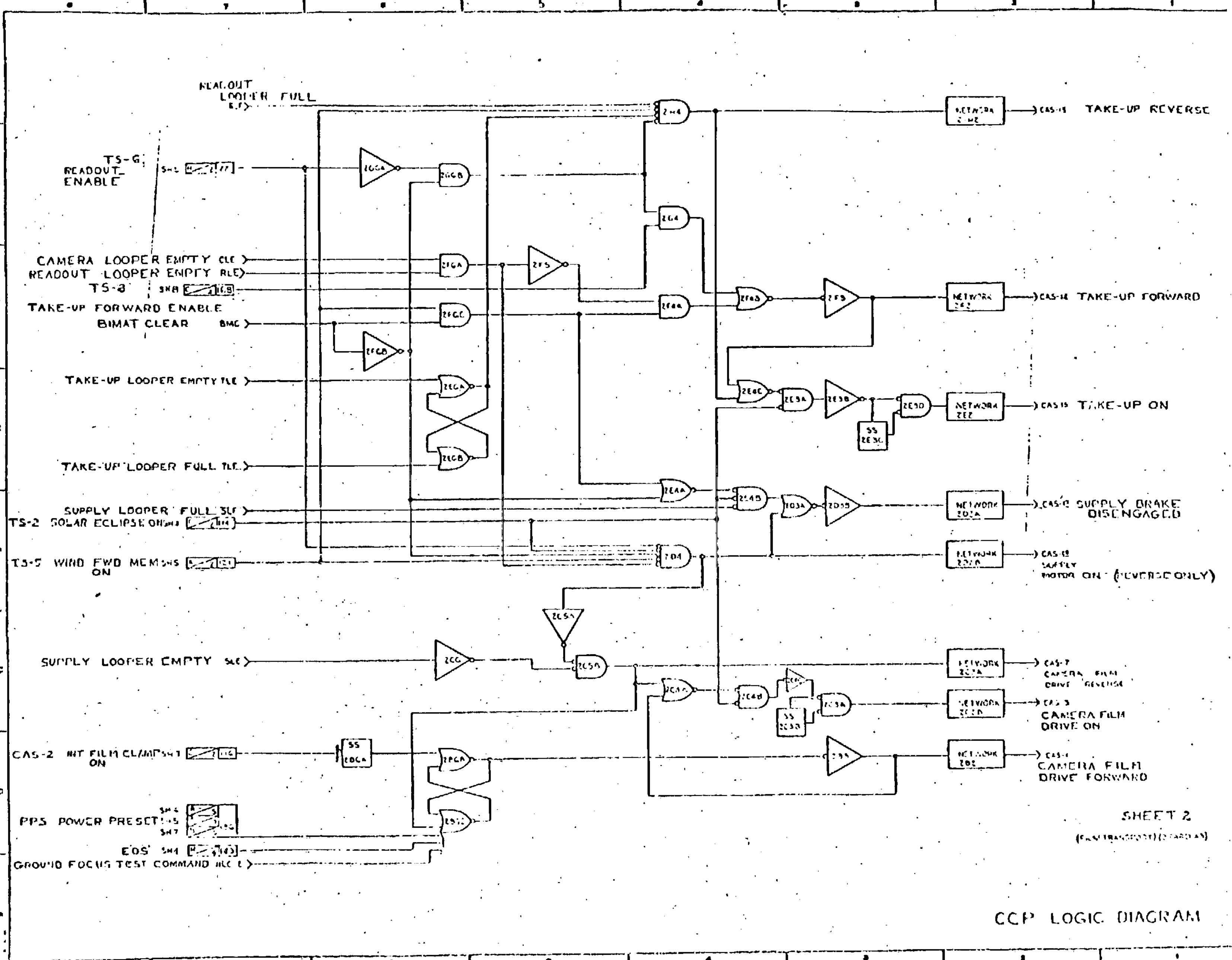
Bernard A. Wittman

BAW:aem

Approved: Bruce L. Eck

I 4

I-025153-RU




SHEET 2

CCP LOGIC DIAGRAM

EASTMAN KODAK COMPANY

APPARATUS AND OPTICAL DIVISION

400 PLYMOUTH AVE. N. ROCHESTER, NEW YORK 14650

N-649500-9572

RECEIVED

DISPOSITION DATE

April 19, 1967

L-025140-OU

The Boeing Company
Space Division
SP Box 3995
Seattle, Washington 98124

Attention: Mr. Robert Ochiltree
Mail Stop 85-54

Subject: Additional Material for PS Fault Isolation Procedures at SFOF

Reference: Boeing TWX 2-4531-02-3626, L-024994-XU, dated 3/23/67

Gentlemen:

Based upon events during Mission III, Kodak was asked to submit additional material on the Photographic Subsystem. The material attached is a condensation and/or restatement of data provided in other Kodak Documents which makes the information more visible and available for SFOF operations personnel.

Enclosure I is a summary of PS heater status in all operational modes. The temperature set points for each heater are nominal values. During a mission it is recommended that the values for the PS being flown be entered. This data is available in the applicable PS data package.

Enclosure II is a summary of the normal power and current drawn by various PS components at a voltage of 30.5 vdc. Initial stall current values for several components are given. These values can be used in conjunction with the heater inhibit status chart to determine the nominal current status of the PS during any PS operation.

Enclosure III gives nominal power profiles for various PS operating modes. Note that these power profiles do not include power drawn by environmental heaters. These power profiles must be used in conjunction with Enclosure I which gives PS environmental heater status.

Enclosure IV gives a procedure for placing the PS in a safe condition for failure analysis. This enclosure also gives a general guide to the nature of potentially catastrophic failures.



TELEPHONES • CAMERA WORKS, AND HAWK-EYE WORKS, AREA CODE 716 325-2000
LINCOLN PLANT, AREA CODE 716 BEverly 5-7770

Enclosure V gives a matrix listing indications of a power interruption or a transient which causes a Preset Power Signal within the PS.

Enclosure VI lists recovery procedures that should be followed to re-establish proper PS logic states after a power interruption.

The data furnished by this letter is the data requested by Part B of OCN-12 to Boeing Work Statement LO-M681154. Part B of OCN 12 was a Statement of Work for Data to Supplement EK PS Fault Isolation diagrams as detailed in reference TWX. This completes Part B of OCN-12. Part A of OCN-12 was completed when a course of instruction on PS operation was presented at Boeing during the week of 4/3/67.

Very truly yours,

EASTMAN KODAK COMPANY

Bruce L. Elle

Research and Engineering

BLElle:PJF:aem

Approved: M Heldman

Enclosure I
L-025140-OU

NOMINAL PHOTO SUBSYSTEM HEATER STATUS
NOTES

1. In the Wind Forward Mode, all P.S. heaters are inhibited while the camera memory is on.

2. In the Bimat Cut Mode, all P.S. heaters are inhibited while the Bimat cut memory is on (from execution of Bimat cut command to BCO, Bimat cutter off, signal).

3. In the Heater Inhibit Mode, the processor and dryer heaters are inhibited unless BME, Bimat enable, signal is present.

4. All PS heaters are normally inhibited during camera operations and during readout, both limited and final.

I = Inhibited

| P.S. HEATER AND SET POINT / P.S. MODE | UPPER SHELL HEATER SET POINT ON 52°F OFF 58°F | LOWER SHELL HEATER SET POINT ON 52°F OFF 58°F | THERMAL FIN #1 SET POINT ON 67.5°F OFF 72.5°F | THERMAL FIN #2 SET POINT ON 67.5°F OFF 72.5 | THERMAL FIN #3 SET POINT ON 67.5°F OFF 72.5°F | CAMERA SHROUD HEATER SET POINT ON 67.5°F OFF 72.5°F | WINDOW HEATER SET POINT ON 67.5°F OFF 72.5°F | LENS HEATER SET POINT ON 67.5°F OFF 72.5°F | PROCESSOR HEATER SET POINT ON 82-2.5 OFF 85+2.5 | DRYER HEATER SET POINT ON 95-5 OFF 95+5 | MAX. CURRENT AMPS / MAX. TOTAL WATTAGE at 30.5V |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V/H Mode | 8.31 | 7.77 | 4.81 | 18.20 | 18.00 | 7.00 | 4.10 | 2.75 | I | I | 70.94 2. |
| Photo Mode with and Without V/H | I | I | I | I | I | I | I | I | I | I | 0 0 |
| Processing Mode | 8.31 | 7.77 | 4.81 | 18.20 | 18.00 | 7.00 | 4.10 | 2.75 | 9.09 | 16.70 | 96.73 3. |
| Limited R/O | I | I | I | I | I | I | I | I | I | I | 0 0 |
| Final R/O | I | I | I | I | I | I | I | I | I | I | 0 0 |
| Wind Forward Mode (See Note 1) | (1) 8.31 | (1) 7.77 | (1) 4.81 | (1) 18.20 | (1) 18.00 | (1) 7.00 | (1) 4.10 | (1) 2.75 | I | I | 70.94 2. |
| Processing Standby | 8.31 | 7.77 | 4.81 | 18.20 | 18.00 | 7.00 | 4.10 | 2.75 | I | I | 70.94 2. |
| Limited R/O Standby | 8.31 | 7.77 | 4.81 | 18.20 | 18.00 | 7.00 | 4.10 | 2.75 | I | I | 70.94 2. |
| Final R/O Standby | 8.31 | 7.77 | 4.81 | 18.20 | 18.00 | 7.00 | 4.10 | 2.75 | I | I | 70.94 2. |
| Bimat Cut (See Note 2) | (2) 8.31 | (2) 7.77 | (2) 4.81 | (2) 18.20 | (2) 18.00 | (2) 7.00 | (2) 4.10 | (2) 2.75 | (2) 9.09 | (2) 16.70 | 96.73 3. |
| Solar Eclipse Mode | I | I | I | 18.20 | I | 7.00 | 4.10 | 2.75 | I | I | 32.05 1. |
| Heater Inhibit On (See Note 3) | I | I | I | I | I | I | I | I | (3) 9.09 | (3) 16.70 | 25.79 0. |

Photographic Subsystem Power Profiles

The attached graphs show a nominal profile of power consumption by the photographic subsystem. Entry into and completion of the major operating modes is shown. Where applicable, cycling of components which are not operating continuously is indicated. These graphs do not show the consumption of power by environmental heaters. The heater inhibit status chart provided shows the temperature set points for heater operation. Power for heaters should be added when applicable.

The profiles shown were based upon an input voltage of 30.5 vdc to the PS. The power shown indicates maximum continuous power drawn by components during non-transient conditions.

For assistance in determining details of power consumption, the PS Component Power Summary sheet can be used. Note that the following components are continuously drawing power in all PS modes of operation.

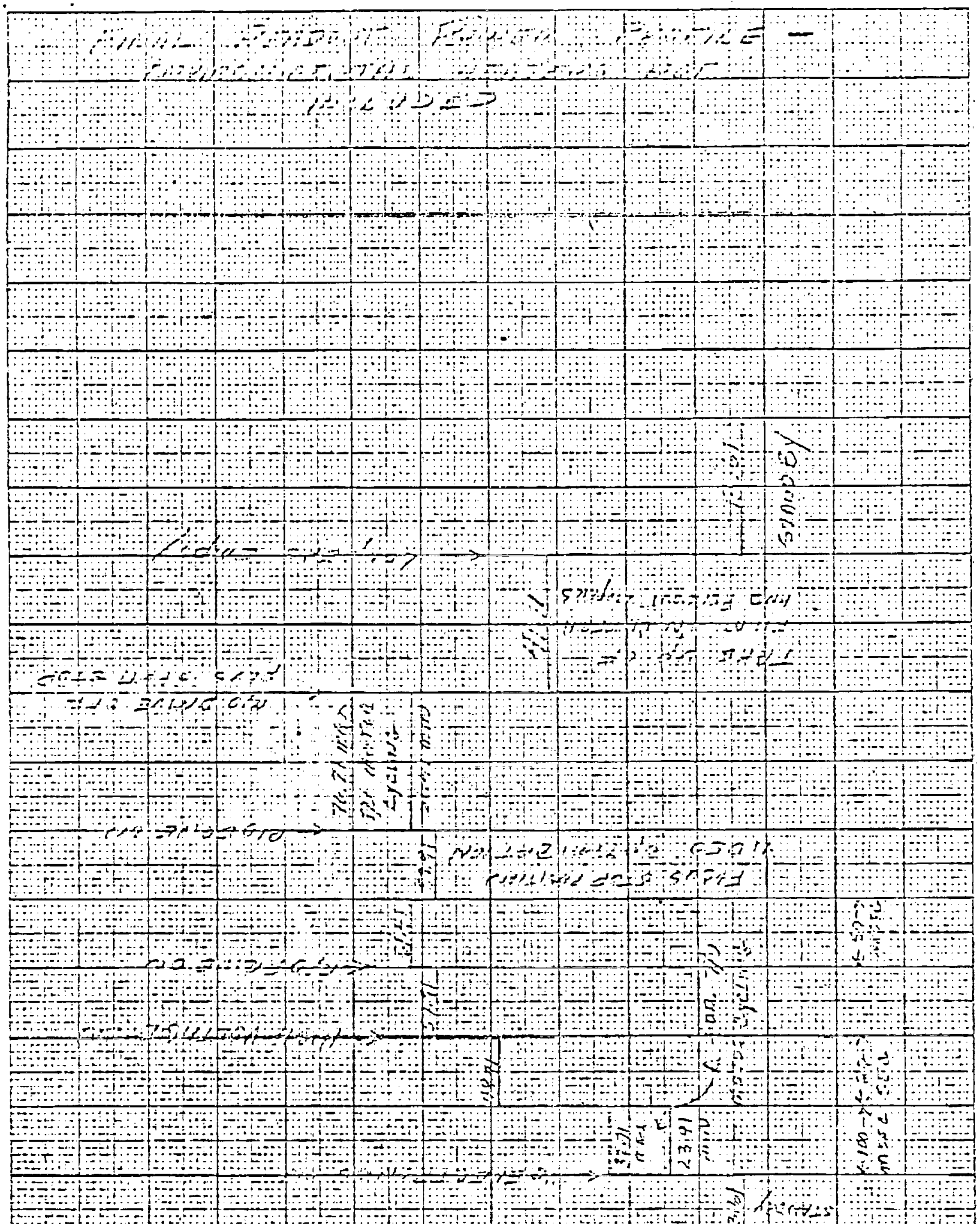
| | |
|---|---|
| Instrumentation | 0.24 watts |
| CCP Control Logic | 1.93 watts |
| Reference Frequency Gen. | 0.14 watts |
| Sweep and Sync Logic | 0.05 watts |
| Reference Voltage Generator | 0.46 watts |
| Continuous Prime Supply Losses | 0.50 watts |
| DC/DC Converter losses | 9.64 watts |
| Heaters Controllers | 0.65 watts |
| Total Standby Power | 13.61 watts |

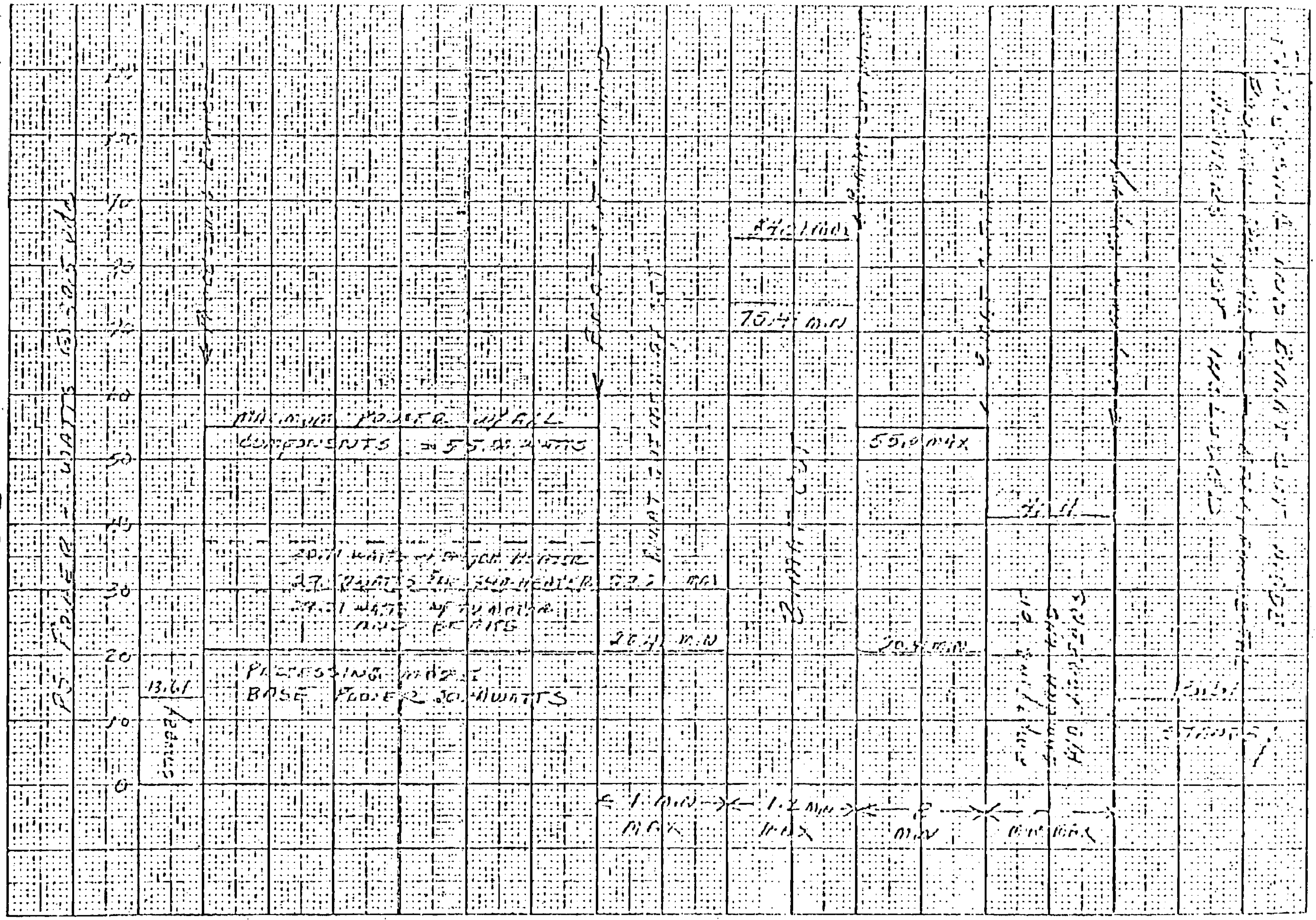
Photographic Subsystem
Component Power Summary (30.5 VDC)

Enclosure II
L-025140-OU

| Component | Normal Wattage | Normal Current (Amps) | Stall Current If Applicable |
|---|---|---|---|
| 80mm Shutter Motor | 6.7 | .219 | .50 |
| 24" Shutter Motor & Solenoid | 24.3 | .796 | .825 |
| 80mm Exposure Adjust Motor | 18.8 | .616 | .670 |
| 24" Exposure Adjust Motor | 9.0 | .295 | .45 |
| Film Advance Motor Brake | 19.9 | .652 | 2.45 |
| V/H Sensor and Electronics | 12.5 | .410 | Note 1 |
| FC & VD Motor | 25.0 | .820 | 1.29 |
| Data Electronics & Pinlight | 0.84 | .0275 | NA |
| Supply-Spool Brake | 6.7 | .219 | NA |
| Supply-Spool Motor | 3.3 | .108 | .40 |
| Take up Motor and Brake | 8.8 | .289 | .50 |
| Supply Spool Clutch | 6.5 | .213 | NA |
| Readout Scanner Clutch | 3.7 | .121 | NA |
| Bimat Drive Motor | 3.1 | .103 | .180 |
| Bimat Cutter | 55.0 | 1.81 | NA |
| Instrumentation | 0.24 | .0787 | NA |
| CCP Control Logic | 1.93 | .0632 | NA |
| Reference Frequency Generator | 0.14 | .0046 | NA |
| Sweep and Sync Logic | 0.05 | .0016 | NA |
| Photomultiplier Tube and Supply | 2.0 | .0655 | NA |
| Reference Voltage Generator | 0.46 | .0151 | NA |
| Video Amplifier | 0.9 | .0295 | NA |
| Sweep, Sync & LST Power | 18.9 | .62 | NA |
| Filament | 3.2 | .105 | NA |
| High Voltage Supply & Beam $I_B$ | 9.0 | .295 | NA |
| Drum Anode Motor | 10.3 | .338 | .40 |
| Readout Scanner Motor | 3.5 | .115 | .220 |
| Continuous Prime Supply Losses | 0.5 | .0164 | NA |
| DC/DC Converter Losses | 9.64 | .316 | NA |
| Camera Shroud & Film Cassette Heater | 7.0 | .229 | NA |
| 24" Lens Heater | 2.75 | .090 | NA |
| 24" & 80mm Window Heater | 4.1 | .134 | NA |
| Upper Pressure Shell Heater | 8.31 | .273 | NA |
| Lower Pressure Shell Heater | 7.77 | .255 | NA |
| Processor Heater | 9.09 | .298 | NA |
| Dryer Heater | 16.7 | .548 | NA |
| Fin Base Area #1 Heater | 4.85 | .159 | NA |
| Fin Base Area #2 Heater | 18.2 | .597 | NA |
| Fin Base Area #3 Heater | 18.0 | .590 | NA |
| Each Heater Controller (10) | 0.065 (0.65) | 0.002 (0.02) | NA |

Note #1: The V/H sensor motors (scanner, memory, sweep and crab) can produce varying stall currents depending upon the V/H rate at the time of stall. The scanner, memory and crab motors associated circuitry will limit stall currents to 120ma per motor. A stalled sweep motor will develop sweep error logic that will drive the sweep control voltage to the upper limit and produce a stall current of 250 ma.




MINIMUM POWER W/ ALL
COMPONENTS = 55.0 WATTS
55.0 MAX
70.4 MIN
26.4 MIN
20.5 MIN
PRESSING MODE
BASE POWER 30 WATTS
13.61
0
10
20
30
40
50
60
70
MAX
MIN

PHOTOGRAPHIC SUBSYSTEM ANOMALIES - GENERAL

In general anomalies in the PS can be categorized as follows:

1) A condition which is non-normal and stable. Examples are: An erroneous total shutter count, an erroneous total film advance for a photographic sequence, a change in processing rate or possibly an erroneous readout looper content.

2) Conditions are non-normal and changing. Examples are: A run away take-up reel, a run away camera which will not stop advancing film or an increasing temperature.

The first category is generally a less dangerous situation with the exception of an anomalous current indication. In general, the first category of failures does not require as rapid attention as the second.

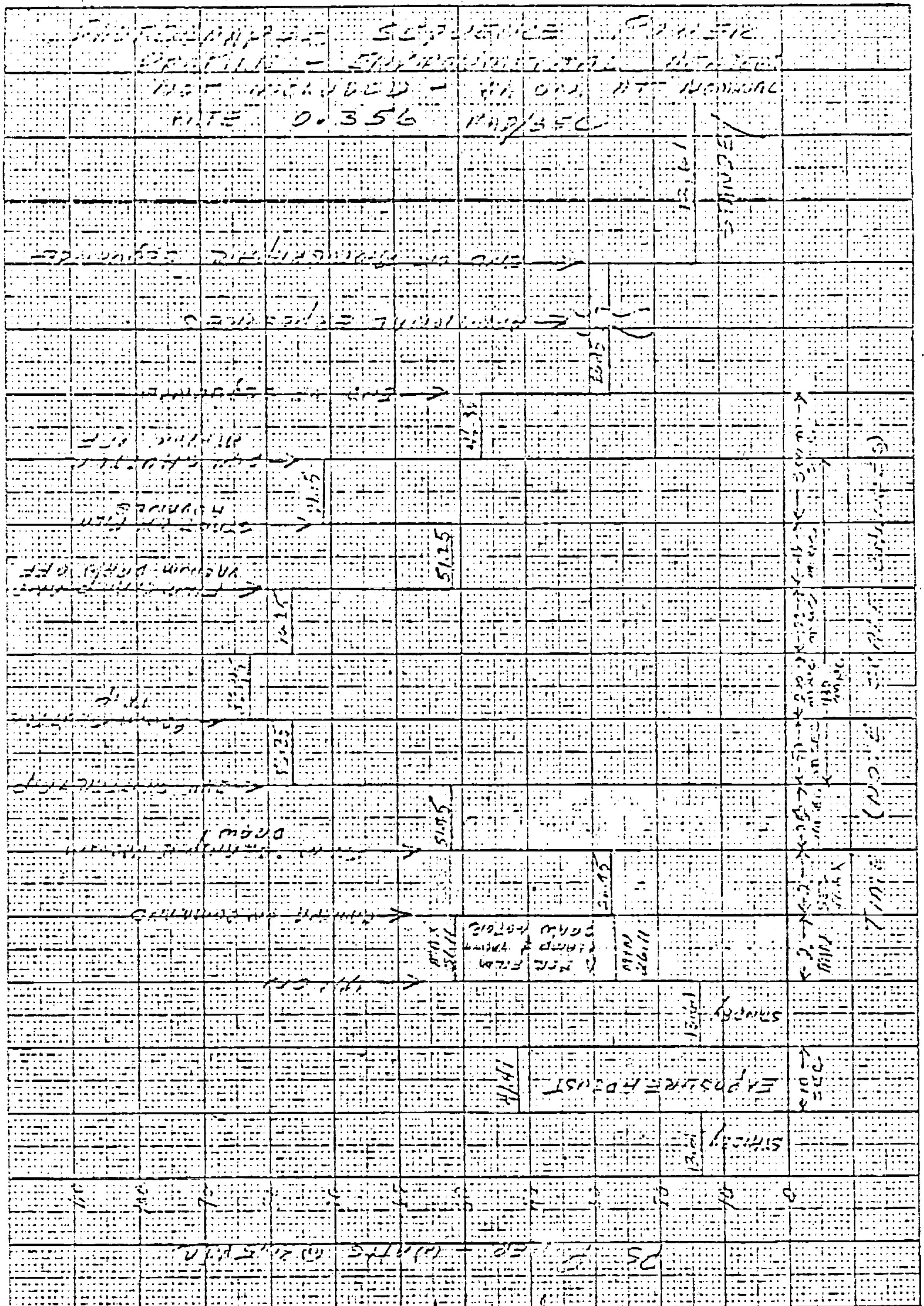
The second category of failures is generally indicative of impending catastrophe and quick action would be required.

Important: The first action that should be taken in the event of an anomaly that cannot be explained immediately and appears to be potentially catastrophic is to issue a Solar Eclipse On command to the PS.

A series of commands is listed which will place the PS in a safe mode for failure analysis for all PS operating modes. The commands are listed in order of effectiveness and in an order which reflects the relative importance of a potential anomaly. The command sequence should be followed and repeated until indication of results is obtained from telemetry. The command sequence is as follows:

1) Solar Eclipse On plus Readout-Drive on
2) Consider necessity of placing programmer in infinite jump (spacecraft)
3) Readout Electronics On
4) V/H Off
5) Readout Drive Off
6) Readout Drive On
7) Camera On
8) V/H Off
9) Heater Inhibit On

Important: The above general listing will cover the majority of anomalous conditions that could arise. It is emphasized that the cognizant analysts should not be required to follow this sequence without exception. Analysts must have the authority to modify the above sequence when in their judgment a better course of action is desirable.


RATE 0.356
EXPOSURE ADJUST
51.25

Enclosure V
L-025140-OU

INDICATIONS OF PHOTO SUBSYSTEM

POWER INTERRUPTION

OR

VOLTAGE TRANSIENT WHICH

CAUSES GENERATION OF A PRESET POWER SIGNAL

The attached matrix represents a simplified method of identifying symptoms of a power interruption in all modes of photo subsystem activity. However, it must be kept in mind that presence of single indication does not determine a photo subsystem power interruption. All indications for each P.S. mode respectively must be present to definitely determine a power interruption. Some of the listed indications are only applicable during mode transitions. These are:

a) V/H Sensor fails to turn on
b) Camera fails to turn on
c) Processing fails to start
d) R/O Electronics fail to turn on

If a power interruption occurs, one of these indications will be present when attempting a mode transition from any of the 3 Standby modes or Wind Forward mode to any other logical P.S. mode excepting the Solar Eclipse mode and the 3 Standby modes.

Most indications listed in the matrix are readily observable by telemetry values. Reset of the shutter speed setting is not. If a power interruption occurs, the shutter speed will not be in sync with the telemetry indication. Cycling through shutter speed setting will provide the required indication. This sequence can be performed in the safe solar eclipse mode.

Enclosure V

PHOTOGRAPHIC SUBSYSTEM

INDICATIONS OF POWER INTERRUPTION

| INDICATION OF POWER INTERRUPTION / PHOTO SUBSYSTEM MODE | V/H SENSOR FAILS TO TURN ON | CAMERA FAILS TO TURN ON | PROCESSING FAILS TO START | R/O ELECTRONICS FAILS TO TURN ON | V/H SENSOR TURNS OFF PREMATURELY | PHOTO SEQUENCE IS NOT COMPLETED | PROCESSING TERMINATES PREMATURELY | R/O TERMINATES PREMATURELY | VIDEO WHITE LEVEL & PM SUPPLY VOLTAGE CHANGES SIGNIFICANTLY | FILM PREMATURELY STOPS EMPTYING FROM R/O LOOPER TO SUPPLY SPOOL | FILM PREMATURELY STOPS EMPTYING FROM CAMERA STORAGE LOOPER TO T/U SPOOL | [illegible] SETTING IN [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V/H Mode | | | | | x | | | | | | | x |
| Photographic Mode with V/H | | | | | x | x | | | | | | x |
| Photographic Mode without V/H | | | | | | x | | | | | | x |
| Processing Mode | | | | | | | x | | | | | x |
| Limited R/O Mode | | | | | | | | x | x | | | x |
| Final R/O Mode | | | | | | | | x | x | | | x |
| Wind Forward Mode | x | x | | x | | x | | | | | x | x |
| Processing Standby Mode | x | x | x | x | | | | | | | | x |
| Limited R/O Standby Mode | x | x | x | x | | | | | | | | x |
| Final R/O Standby Mode | x | x | | x | | | | | | x | | x |
| Bimat Cut Mode | | | | | | | x | | | | | x |
| Solar Eclipse Mode | | | | | | | | | | | | x |

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L-025140-53

PHOTO SUBSYSTEM

RECOVERY PROCEDURES FROM

POWER INTERRUPTION

OR

VOLTAGE TRANSIENTS WHICH CAUSE GENERATION

OF A PRESET POWER SIGNAL

I - 19

TABLE I

| MODE | RECOVERY SEQUENCE |
| --- | --- |
| a) V/H mode before Bimat clear | 1) Execute solar eclipse on command |
| b) Photographic Mode with and without V/H | 2) Verify all indications of power interruption |
| c) Processing Mode | 3) Determine if necessary to jump programmer to prevent execution of SPC S.E. off. Jump programmer if necessary. |
| d) Processing Standby Mode | 4) Execute Wind Forward On then R/O Drive On. |
| e) Bimat Cut Mode | 5) Re-establish shutter speed logic. |
| f) Limited R/O Mode after R/O Electronics On Command | 6) Execute Solar Eclipse Off and return to normal operation. |
| g) Limited R/O Mode after 2nd R/O Drive On Command | 7) Re-establish focus and gain settings during next scheduled R/O. |
| h) Limited R/O Standby | |
| i) Solar Eclipse Mode before Bimat clear | |

TABLE II

| MODE | RECOVERY SEQUENCE |
| --- | --- |
| a) Limited R/O after 1st R/O Drive On Command. | 1) Execute Solar Eclipse On command |
| | 2) Execute R/O Drive On and verify R/O Electronics go off. |
| | 3) Perform steps 2 through 7 of Table I |

## TABLE III

| MODE | RECOVERY SEQUENCE |
|---|---|
| a) V/H Mode after Bimat Clear | 1) Execute S.E. On Command |
| b) Wind Forward Mode | 2) Verify all indications of power interruption |
| c) Final R/O after R/O Electronics On Command | 3) Determine if necessary to jump programmer to prevent execution of SPC S.E. off. Jump programmer if necessary |
| d) Final R/O after 2nd R/O Drive On Command | 4) Program single frame camera mode |
| e) Final R/O Standby Mode | 5) Execute Camera On Command. |
| f) Solar Eclipse Mode after Bimat Clear | 6) Execute Solar Eclipse Off Command. |
| | 7) As soon as possible after step #6, execute Camera On Command. |
| | 8) Execute Bimat Cut Command and Return to Normal Operation. |
| | 9) Re-establish focus and gain settings during next scheduled R/O. |

## TABLE IV

| | |
|---|---|
| a) Final R/O after 1st R/O Drive On Command. | 1) Execute Solar Eclipse On Command |
| | 2) Execute R/O Drive On Command and verify R/O Electronics go off. |
| | 3) Perform steps 2 through 9 of Table III. |

# SECTION 1
# INTRODUCTION

## 1.1 GENERAL

The purpose of this document is to present selected pertinent data concerning the Photo Subsystem (PS) under one cover. The document is intended to serve as (1) an aid in gaining an over-all knowledge of the PS, and (2) a quick, ready reference for operations support personnel in the field. The document is divided into the following eight major sections:

| Section | Topic |
|---|---|
| 1 | Introduction |
| 2 | The Photo Subsystem: PS operational description, component descriptions, sketches, schematic drawings, photographs, etc. |
| 3 | Commands: Command subsystem, method of commanding, format, etc. |
| 4 | Video Telemetry: Description of system, composite video signal. |
| 5 | Function Telemetry: PS telemetry points, description of TLM link, typical schematic drawings. |
| 6 | Resolution and Smear: Definitions, predicted optical performance, tri-bar vs crater resolution. |
| 7 | Exposure: Photometric function, shutter speed vs solar phase angle, tone reproduction data. |
| 8 | Numerical Summary |

Various sections of the document will be redundant with other sections at times; this was done for the sake of clarity and to preserve the integrity of each section.

The document was produced during the period 27 December 1965 to 15 March 1966.

## 1.2 MISSION AND OBJECTIVES OF THE PHOTO SUBSYSTEM

The primary objective of the Lunar Orbiter missions is to obtain topographic data of the lunar surface to aid in the selection of landing sites for the Apollo mission. Secondary mission objectives are to secure information about the size and shape of the moon, the properties of its gravitational field, and lunar environmental data.

A two-stage launch vehicle consisting of an Atlas (SLV-3) primary booster and an Agena D (Model SS01B) second stage will boost the spacecraft into a translunar trajectory via an earth parking orbit. Shortly after separation from the Agena, the spacecraft will deploy solar panels and antennas and maneuver to acquire the sun, ensuring power and communications. After passing through the Van Allen belt (after about 6 hours of flight), the Canopus sensor will be turned on and a star mapping procedure will take place to ensure positive identification and acquisition of Canopus. The attitude control subsystem will make commanded maneuvers and maintain spacecraft attitude throughout the remainder of the mission, using reference information provided by the Sun and Canopus sensors. Based on analysis of tracking data, one or more mid-course correction maneuvers may be executed using the velocity control subsystem.

As the spacecraft approaches the moon, the velocity control subsystem will be used to inject the spacecraft into an initial lunar orbit. Approximate parameters for this orbit are:

| | |
|---|---|
| Inclination | 12.5 degrees |
| Apolune | 1850 km |
| Perilune | 200 km |

The spacecraft will occupy this orbit while tracking data is acquired to analyze the characteristics of the lunar gravitational field before transfer to the lower altitude final orbit. Photographs can be taken while in the initial orbit and read out to determine the necessity for adjustments to the PS read-out system.

After sufficient data has been acquired from the initial orbit, the velocity-control subsystem will be used to place the spacecraft in a final orbit. The approximate parameters of this orbit are:

| | |
|---|---|
| Inclination | 12.5 degrees |
| Apolune | 1850 km |
| Perilune | 46 km |

The spacecraft will then be commanded to take appropriate photographic sequences as it passes over predetermined areas. Between photographic passes, limited read-out can be commanded to verify correct operation of the spacecraft, if time permits. When film exposure and processing has been completed, the read-out of all photographic frames will take place during earth/sun viewing periods.

# SECTION 2
# PHOTO SUBSYSTEM

The purpose of this section is to describe the operation of the Photo Subsystem (PS) in detail and to include a detailed description of the major PS components. Schematic drawings, logic diagrams, and photographs are included.

## 2.1 OPERATION OF THE PHOTO SUBSYSTEM

The PS is designed to photograph the lunar surface, process the exposed film, scan the processed film with a flying spot, and provide video signals to the communications subsystem for transmission to the earth.

The specified PS photographic requirements are to obtain:

a. Photographs of 8,000 square kilometers of the lunar surface at a ground resolution of one meter.

b. Photographs of 40,000 square kilometers of the lunar surface at a ground resolution of eight meters.

The subsystem must operate within constraints imposed by power, film supply, earth/solar eclipse conditions, film set and Bimat stick contraints, and processor and read-out speeds. The system is designed to conform with the weight specification of 137 pounds.

To accomplish these objectives, the PS uses two separate lens systems to photograph the moon simultaneously at both high (one meter) and moderate (eight meters) resolution. Both lenses photograph in discrete frames

rather than in long strips as is the case with some aerial camera systems. The number of frames to be exposed can be selected through commands to the PS Command Control and Programmer unit (CCP).

The high resolution lens is a 24-inch focal length, 6-element refractor having a relative aperture of f/5.6. To reduce image smear to an acceptable level, image motion compensation (IMC) is provided with the platen moving approximately 0.3 inch at the correct velocity during the exposure. The platen movement is limited to one direction (parallel to the film width) by the camera. Spacecraft attitude control is used to align the platen and image motion vectors. The 24-inch lens system uses a focal-plane shutter whose curtain velocity is constant at all exposures. Slit widths of 2, 1, and 1/2 inch are programmable to provide nominal exposure times of 1/25, 1/50 and 1/100 second, respectively. The moderate-resolution lens is a commerical Schneider Xenotar having a focal length of 80mm and stopped down to a relative aperture of f/5.6. A between-the-lens leaf shutter is used with this lens, providing exposure times of 1/25, 1/50, and 1/100 second. IMC is also used with this system, with the platen moving at the correct velocity as with the 24-inch system. The IMC velocity required for each lens is determined by the V/H (velocity/height) sensor whose output is in the form of a cam which drives the 24-inch platen whenever the V/H is operating. The 80-mm platen is coupled to the 24-inch platen by a lever arm which drives it at a reduced velocity to provide IMC. The relationship is:

$$\frac{\text{Velocity}}{\text{Height}} = \frac{\text{platen velocity}}{\text{lens focal length}}$$

The drive velocity for the 80-mm platen will therefore be slower than the 24-inch platen drive velocity by a factor of 7.6.

As photographs are taken at controlled intervals, the exposed film moves rapidly into the camera storage looper. At the completion of photography, these frames are drawn out of the camera storage looper and are processed, dried, and wound onto the take-up reel. Processing takes place at a nominal rate of 2.4 inches/minute. The camera storage looper has a capacity of approximately 20 frames, each of 11.7 inches length.

Two modes of photographic data transmission are provided by the PS design. In the first mode, called the limited read-out mode, film is wound off the take-up reel, scanned by the read-out system, the video data transmitted, and the scanned film stored temporarily in the read-out looper. The read-out looper has a maximum film capacity equal to 4 frames. When the information contained on these four frames has been transmitted, the film is wound back onto the take-up reel. Final photographic read-out, the second mode, is performed by cutting or utilizing all the Bimat in the processor and running the film backwards through the system during read-out. The read-out looper is used in conjunction with the camera storage looper during final read-out to sense tension and to control the motor in the supply spool (which takes up the read-out film).

Read-out is accomplished through the use of the read-out chain. A small (6.5-micron diameter) spot produced by a cathode ray tube and condensing optics is swept across a strip of the developed film for a distance of 0.105 inch, parallel to the long dimension of the film. The density variations of the negative film produce variations in the brightness of the transmitted spot. The transmitted (modulated) light signal is input to a photomultiplier tube and converted to an electrical signal which is then amplified, transmitted to the ground, and reconstructed to produce a photographic image. The spot sweep takes place at the rate of 800 cps, with the spot being blanked during the sweep return. The spot is advanced across

the film by moving the condensing lens at a uniform rate across the width of the film through a distance of about 60 mm. Film scan is thereby accomplished electrically at a sweep rate of 800 cps and mechanically at a sweep rate of approximately 0.3 cps (one complete scan every 22.02 seconds).

During read-out, the negative film is advanced sequentially through the read-out gate in 0.100-inch increments, called framelets. Since 0.105-inch increments are covered by the flying spot, a certain amount of overlap between framelets will occur. The scanning rate is such that approximately 46 minutes are required to transmit an entire photographic frame (consisting of one high and one moderate-resolution photograph) to the earth.

Additional detail concerning the operation of the PS components is contained in paragraph 2.2. A detailed description of the sequence of events and the various modes of operation is given in paragraph 2.3. A block diagram of the PS is given in Figure 2-1.

## 2.2 MAJOR COMPONENTS OF THE PHOTO SUBSYSTEM (See 2.7 for photographs of the Components discussed in this paragraph)

### 2.2.1 Command, Control and Programmer (CCP)

The CCP is the component within the PS which controls most of the PS functions, acting as an interface between the Boeing command subsystem and the PS. The CCP receives the commands from Boeing and, through the use of digital logic, produces control signals to operate the PS. All PS commands are routed through the CCP except those associated with performance adjustments (Camera Shutter Advance, Line Scan Tube Focus, and Photo Video Gain).

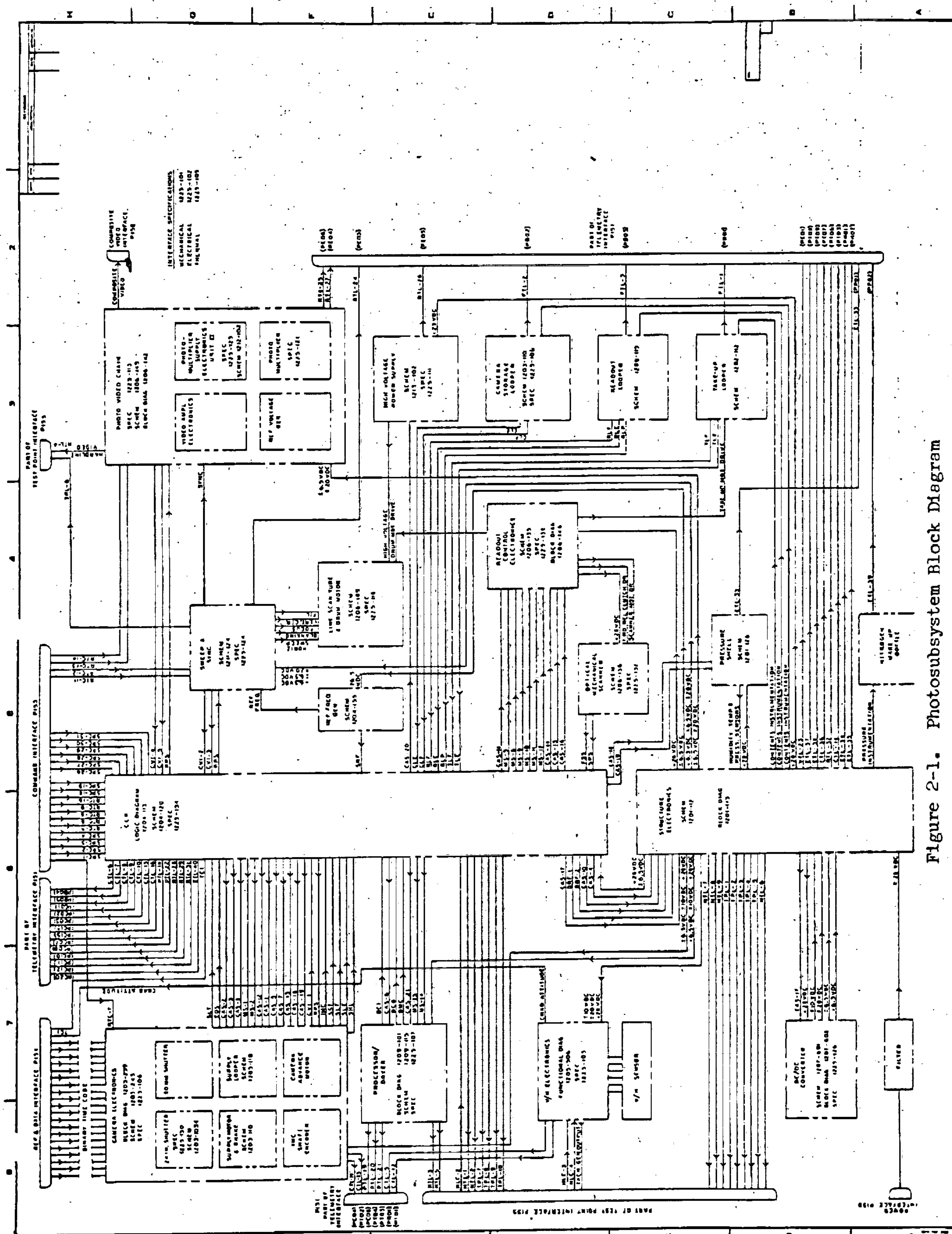

Figure 2-1. Photosubsystem Block Diagram

In addition, the CCP is the source of most of the digital telemetry data which is used to indicate the mode of operation, the number of frames taken, and the verification of commands.

The CCP operation can be described by referring to eleven modes of PS operation. These modes, which are listed below, are described in paragraph 2.3, Modes of Operation.

| Mode | Description |
|---|---|
| Photographic | Camera is ON. |
| V/H | V/H sensor is operating. |
| Processing | Processing is taking place. |
| Processing standby | Processing could occur but no film has been exposed. |
| Quick-look read-out standby | Processing is inhibited by the read-out release and read-out is not taking place. |
| Quick-look read-out | Read-out electronics memory ON or spot-stop switch OPEN, and Bimat has not cleared the processing drum. |
| Final read-out | Same as quick-look read-out but the Bimat has cleared the processing drum. |
| Final read-out standby | Bimat cleared, wind-forward memory OFF, the read-out electronics memory OFF, and the spot-stop switch CLOSED |
| Bimat cut | Bimat cut occurs, and Bimat clears the processing drum |
| Wind forward | After bimat cut and clear, film transport logic switched to enable movement toward the take-up reel. |
| Solar eclipse | PS operational mode when spacecraft is not viewing the sun. All PS operations inhibited except standby power and minimum environmental power. |

Five tables concerned with CCP inputs and outputs are included as Tables 2-1 through 2-5. For convenience, each table is described briefly below.

| Table | Description |
|---|---|
| 2-1 | A list of the input commands to the CCP from Boeing, along with one hard-line command which comes through the test point connector. |
| 2-2 | A list of the telemetry points which are output from the CCP. The telemetry monitors are separated into two groups, one for command verification, and one for function monitoring. |
| 2-3 | A list of the control signals which are provided to the PS by the CCP in response to the commands from Boeing in Table 2-1. |
| 2-4 | A list of the input signals which the CCP requires from the PS to provide telemetry monitoring of the internal state of PS components. A reference frequency input is used by the CCP to provide 50-cycle and 400-cycle power to the PS, and to generate 400-cycle timing data. |
| 2-5 | A list of the 6 outputs from the CCP to the test point. |

### 2.2.2 V/H Sensor

The V/H sensor is an electro-optical device which measures the rate and direction of image motion appearing in the image plane of the 24-inch lens. Because image motion results from the velocity of the spacecraft with respect to the lunar surface, and because the image-motion rate is also dependent on the distance (altitude) of the spacecraft from the lunar surface, the V/H sensor output is directly proportional to vehicle velocity and inversely proportional to object distance (vehicle altitude).

The V/H sensor has two outputs. One is a mechanical shaft rotation proportional to image motion which drives the camera platens through a cam and lever arrangement. The second is a d-c voltage proportional to the misalignment of the image velocity vector and the camera-platen velocity vector. This electrical output is the crab-attitude error voltage. The crab-attitude error voltage is input to the attitude control subsystem

TABLE 2-1

CCP INPUT COMMANDS FROM BOEING COMMAND SUBSYSTEM

| EKC Designation | Function | Action |
|---|---|---|
| SPC-1 | V/H | ON |
| SPC-4 | V/H | OFF |
| SPC-2 | Camera | ON |
| SPC-3 | Read-out electronics | ON |
| RTC-5 | Read-out drive | ON |
| RTC-6 | Read-out drive | OFF |
| RTC-8 | Cut Bimat-end photography | ON |
| RTC-9 | Inhibit all heaters | ON |
| RTC-16 | Wind forward | ON |
| SPC-18 | Solar eclipse | ON |
| SPC-19 | Solar eclipse | OFF |
| SPC-26 | Fast camera rate | Sets camera framing rate |
| SPC-27 | Slow camera rate | Sets camera framing rate |
| SPC-28* | Frame count A | Sets number of exposures |
| SPC-29 | Frame count not A | Sets number of exposures |
| SPC-30 | Frame count B | Sets number of exposures |
| SPC-31 | Frame count not B | Sets number of exposures |

In addition, there is one command input from the test-point connector to the CCP. This command is HLC-2, Focus Test Command, and its function is to inhibit film advance after exposure. It is used during test only.

*One each of commands SPC 28 or 29 and SPC 30 or 31 are given as a two-bit binary code to specify the number of exposures to be taken.

TABLE 2-2

CCP TELEMETRY OUTPUTS

Command Verification Telemetry

| TBC* Designation | EKC Designation | Function | Associated Commands-EKC Designation |
|---|---|---|---|
| PC01 | CTL-8 | V/H ON/OFF | SPC-1, SPC-4 |
| PC02 | CTL-9 | Camera ON | SPC-2 |
| PC 15 | CTL-15 | Frame rate or<br>Camera exposure | SPC-26<br>RTC-7, SPC-27 |
| PC 16 | CTL-16 | Solar eclipse ON<br>OFF | SPC-18<br>SPC-19 |
| PC09 | PTL-22 | Cut Bimat - end photography | RTC-8 |
| PC10 | RTL-28 | Read-out electronics ON or<br>Wind forward | SPC-3<br>RTC-16 |
| PC11 | RTL-29 | Read-out drive ON<br>OFF | RTC-5<br>RTC-6 |
| PC12 | RTL-31 | Line scan tube focus,<br>Photo video gain | RTC-11, RTC-12<br>RTC-13, RTC-14 |
| PC20 | ETL-40 | Inhibit all heaters | RTC-9 |

Function Monitoring Telemetry

| | Designation | Function | Remarks |
|---|---|---|---|
| PB04 | CTL-6-1 | Shutter | 0-31 electronic counter (binary) |
| | CTL-6-2 | | |
| | CTL-6-4 | | |
| | CTL-6-8 | | |
| | CTL-6-16 | | |

* The Boeing Company

TABLE 2-2 (Continued)

| TBC Designation | EKC Designation | Function | Remarks |
|---|---|---|---|
| PB05 | CTL-7-1 | Platen | 0-31 electronic counter (binary) |
| | CTL-7-2 | | |
| | CTL-7-4 | | |
| | CTL-7-8 | | |
| | CTL-7-16 | | |
| PC03 | CTL-10a | Camera program setting logic | Camera framing rate (CTL-10a) and frame count (CTL-10b and c) |
| | CTL-10b | | |
| | CTL-10c | | |
| PC07 | PTL-18 | Bimat clear | Switch |
| | | Other Telemetry | |
| | TCI | Time code interrogation | |

TABLE 2-3

CCP OUTPUT SIGNALS TO THE PS

| Control Signals EKC Designation | Applicable Subassembly | Function |
|---|---|---|
| CAS-1 | Camera electronics | Camera film drive forward |
| CAS-2 | Camera electronics | Draw vacuum and clamp film |
| CAS-3 | Camera electronics | 80-mm shutter |
| CAS-4 | Structure electronics | V/H relay state (Enable logic shutter also present but no longer used) |
| CAS-5 | Camera electronics | Camera film drive OFF/ON |
| CAS-6 | Processor/dryer | Bimat cut |
| CAS-7 | Camera electronics | Camera film drive, reverse |
| CAS-8 | Camera electronics | 24-inch shutter |
| CAS-10 | Structure electronics | Relay state, read-out electronics |
| CAS-11 | Read-out control electronics | R/O forward release |
| CAS-12 | Camera electronics | Supply brake ON/OFF |
| CAS-13 | Camera electronics | Supply motor ON/OFF |
| CAS-14 | Read-out control electronics | Take-up forward |
| CAS-15 | Read-out control electronics | Take-up reverse |
| CAS-16 | Read-out control electronics | Take-up ON/OFF |
| CAS-17 | Structure electronics | ±20 and +6.3 volt converter ON/OFF |
| CAS-18 | Heater controls on pressure shell | Heater inhibit, day |
| CAS-19 | Heater controls on pressure shell | Heater inhibit, night |
| CAS-20 | High voltage power supply | High voltage converter ON/OFF |
| CAS-21 | Processor/dryer | Processor dryer heater ON/OFF |

TABLE 2-3 (Continued)

| Motor Signals EKC Designation | Applicable Subassembly | Function* |
|---|---|---|
| MS-1 and MS-2 | Camera electronics | 24-inch shutter motor |
| MS-5 and MS-6 | Read-out control electronics | Scanner motor |
| MS-13 and MS-14 | Processor/dryer | Bimat motor |
| MS-9, MS-10, MS-11, MS-12 | Read-out control electronics | LST anode motor |
| Other Signals | | |
| PPS | Camera electronics, photo video chain, and sweep & sync | Power preset signal |
| ORF 1, 2 | Structure electronics | Reference frequency for humidity sensor |

* See paragraph 2.5 for an explanation of the function of the motor signals

TABLE 2-4

CCP INPUT SIGNALS FROM THE PS

Command Verification Input Signals

| Designation | Function | Command Item | Telemetry Item EKC Designation |
|---|---|---|---|
| CVI-1 | Camera exposure increase | RTC-7 | CTL-15 |
| CVI-2 | Line scan tube focus increase | RTC-11 | RTL-31 |
| CVI-3 | Line scan tube focus decrease | RTC-12 | RTL-31 |
| CVI-4 | Photo video gain increase | RTC-13 | RTL-31 |
| CVI-5 | Photo video gain decrease | RTC-14 | RTL-31 |

PS Switch Input Signals

| Signal Designation | Function | Subassembly |
|---|---|---|
| SLF | Supply looper full | Supply looper |
| SLE | Supply looper empty | Supply looper |
| CLF | Camera looper full | Camera looper |
| CLE | Camera looper empty | Camera looper |
| RLF | Read-out looper full | Read-out looper |
| RLP | Read-out looper partial | Read-out looper |
| RLE | Read-out looper empty | Read-out looper |
| TLF | Take-up looper full | Take-up looper |
| TLE | Take-up looper empty | Take-up looper |
| BMC | Bimat clear | Processor/dryer |
| SPS | Spot stop | Optical mechanical scanner |
| IMC | Draw vacuum and clamp film (DV & CF) | V/H intervalometer |
| SST | Shutter start | V/H intervalometer |
| SHL | Shutter limit 80mm | 80-mm Shutter |

TABLE 2-4 (Continued)

| Signal Designation | Function | Subassembly |
|---|---|---|
| EOS | End of film advance | Camera advance metering encoder |
| BCO | Bimat cut power OFF | Processor/dryer drum |
| BCI | Bimat cut inhibit | Processor/dryer drum |
| SLT | 24-inch shutter limit switch | 24-inch shutter |
| FSS | Focus stop | Optical mechanical scanner |
| | Other | |
| SRF | Reference frequency input | Reference frequency generator |

TABLE 2-5

CCP TEST POINT OUTPUTS

| Designation | Function |
|---|---|
| TPL-7 | Reference frequency |
| TPL-8 | CCP output 1 (solar eclipse memory) |
| TPL-9 | CCP output 2 (wind forward memory) |
| TPL-10 | CCP output 3 (camera memory) |
| HTL-1 | 24-inch shutter action |
| HTL-2 | 24-inch platen motion |

to provide a control signal for spacecraft yaw (crab) attitude. (See Figure 2-2 for a functional diagram of the V/H sensor.)

The V/H sensor consists of the following components:

a. Scanner head
b. Scanner carriage
c. Scan optics
d. Optics carriage
e. V/H structure

2.2.2.1 Operation of the Sensor. The V/H sensor views the lunar surface through a portion of the field of the 24-inch lens which is outside the normal image format. A small (1/8-inch diameter) circular aperture, located near the edge of a rotating disk, transmits light rays from the lens image plane to a photomultiplier tube through a series of mirrors which are attached to the disk. The disk rotates at 4000 rpm. The effect of the scanning process is to sweep out an annular ring on the lunar surface (at the rate of one scan every 0.015 second). Figure 2-3 is a sketch of the V/H sensor operation. The photomultiplier tube responds to variations in the lunar surface brightness within the annular ring, producing a time-varying electrical output. This output is then quantized by passage through a Schmitt trigger. The output of the trigger essentially reduces the scene output to either white or black. If the light intensity is above a predetermined level, the trigger produces a fixed voltage (+a, or black). This quantized signal is then fed to the processing circuitry.

Between two successive rotations of the scanner disk, corresponding portions of the lunar scene will have moved slightly as a result of normal image motion produced by the movement of the spacecraft. The sensor contains tracking optics which shift the image, opposing the motion of the image, and attempt to reduce the scene shift between scans to zero. This action also is illustrated in Figure 2-3.

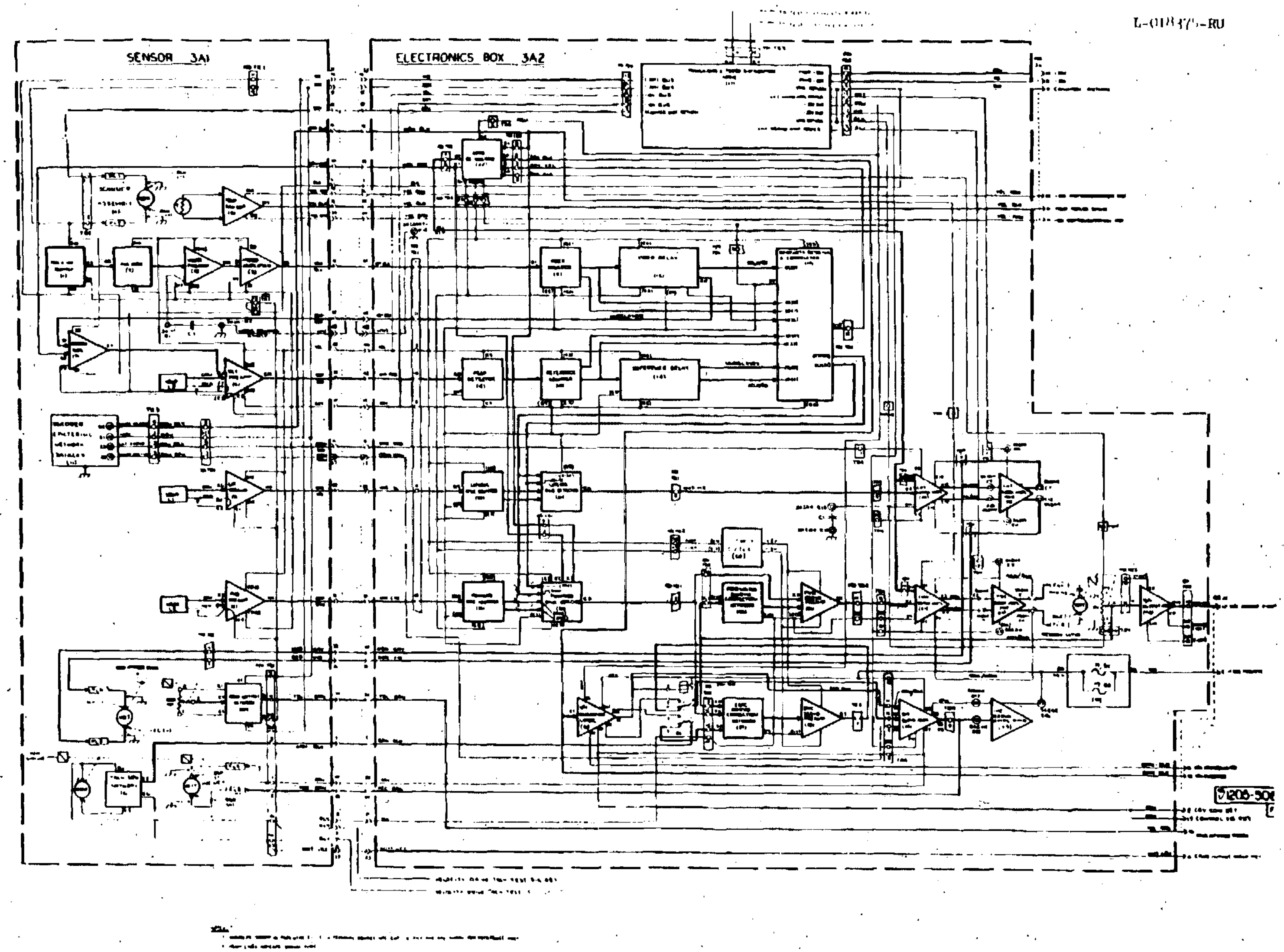


Figure 2-2. V/H Functional Diagram

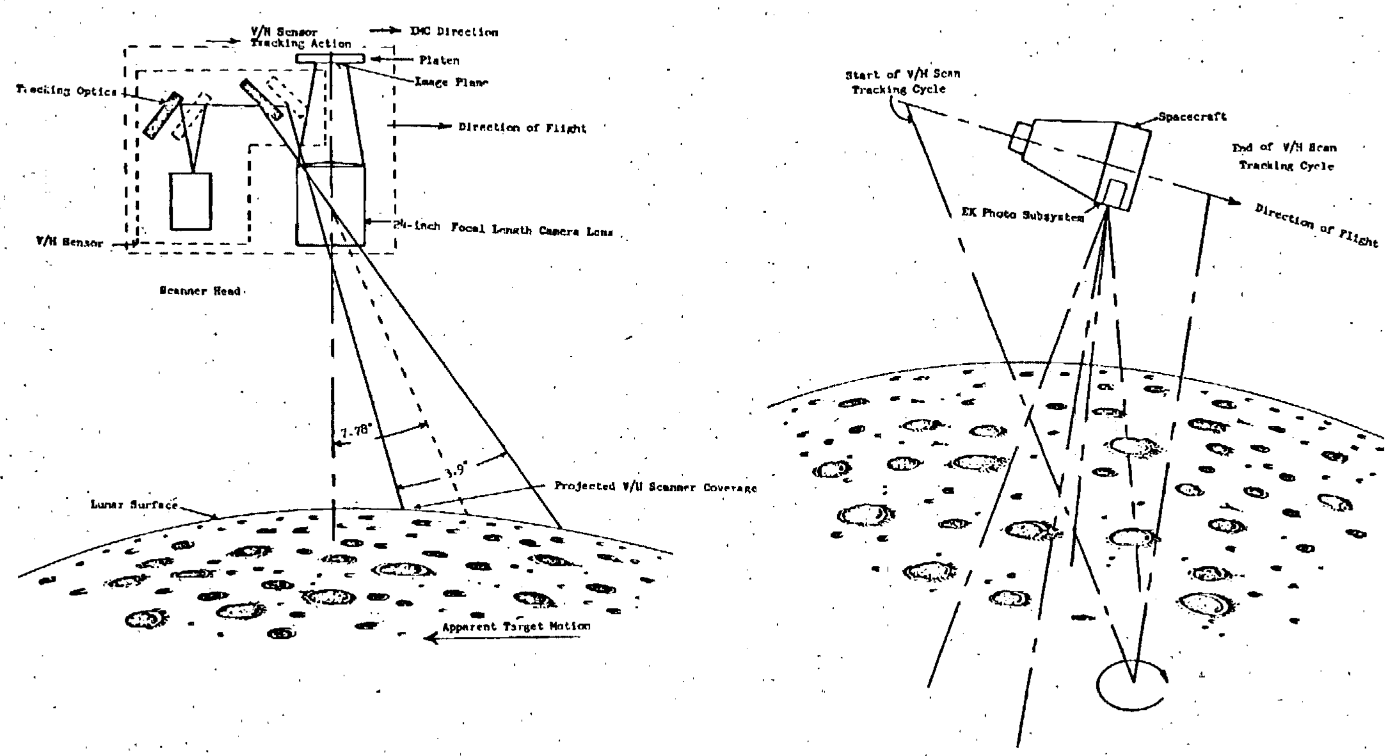


Figure 2-3. Sketch of V/H Sensor Operation

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The V/H tracking mirrors are moved by a closed-loop servo system in response to an error signal. When the error signal is zero, the tracking optics are shifting the image at the precise velocity required to null the velocity of the image. The mechanism which moves the tracking mirrors provides an output (a mechanical cam-shaft rotation) to the 24-inch platen, which drives the platen at the correct velocity and compensates for image motion during the exposure. The 24-inch platen, in turn, drives the 80-mm platen, by means of a lever arm, which reduces the IMC motion of the 80-mm platen by a factor of 7.6.

When the tracking mechanism reaches the travel limit, it is returned to its initial position to track another portion of the surface. During the retrace time, the V/H output shaft continues to rotate at the last determined value of V/H. After the viewing mechanism has been reset, it is again driven forward, at the last determined value of V/H, until a new, usable, error signal is obtained. The previous tracking speed is, in this manner, corrected for any change in V/H.

The V/H sensor is capable of following a step change of 1.0 percent with a time constant of approximately 2 seconds. The sensor can operate at an average V/H rate-of-change (slewing speed) of 1.5 percent/second, or greater when subjected to step change in V/H of 50 percent.

2.2.2.2 Development of the Error Signal. The quantized electrical output of the Schmitt trigger (see Figure 2-4) is fed to the processing circuitry. A block diagram of this circuitry is shown in Figure 2-5.

For the first few scans of the sensor, the switch in Figure 2-5 is in position 2; the quantized signal is alternately recorded and erased on the magnetic drum which is run synchronously with the scanner (actually, the

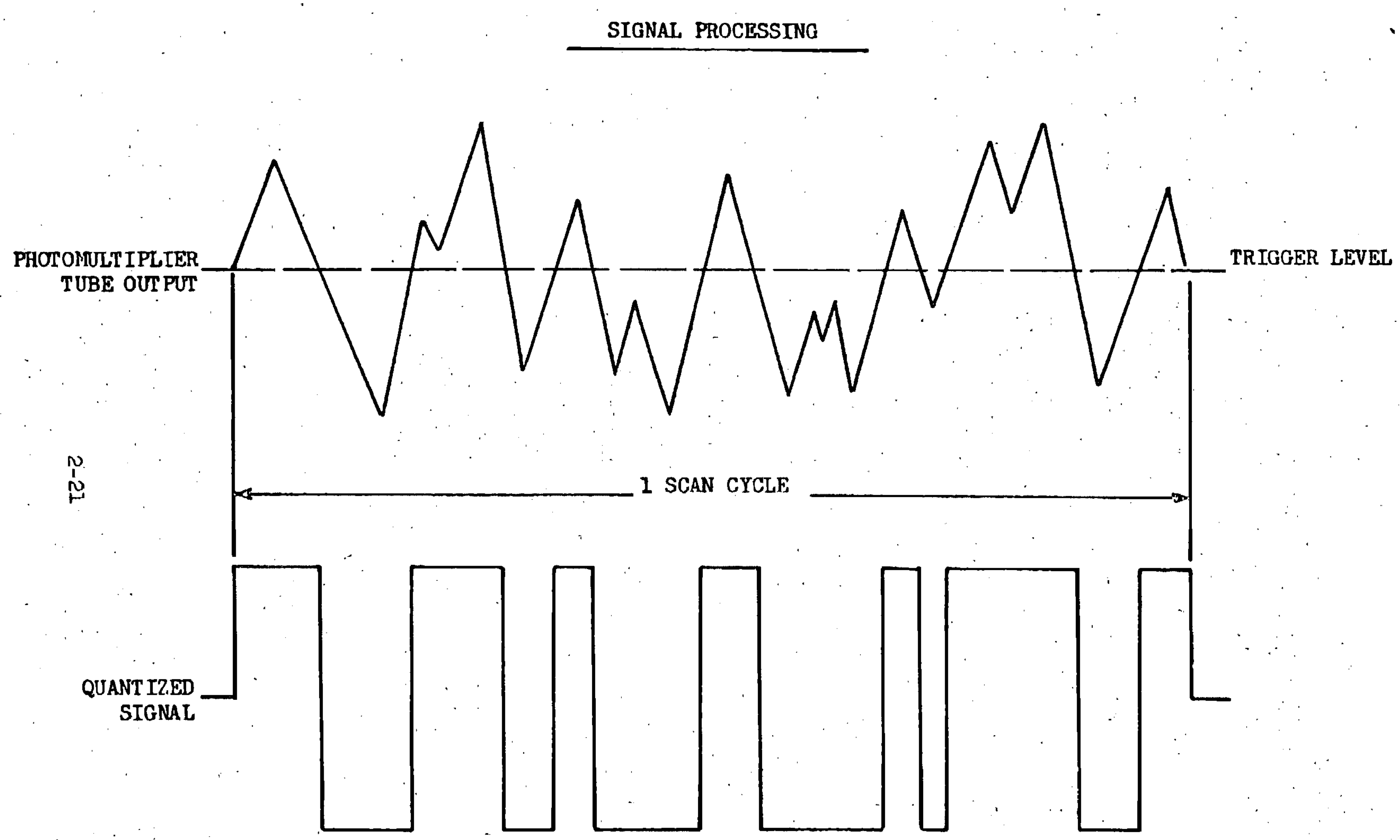



Figure 2-4. Operation of the Schmidt Trigger for Quantizing the Photomultiplier Output

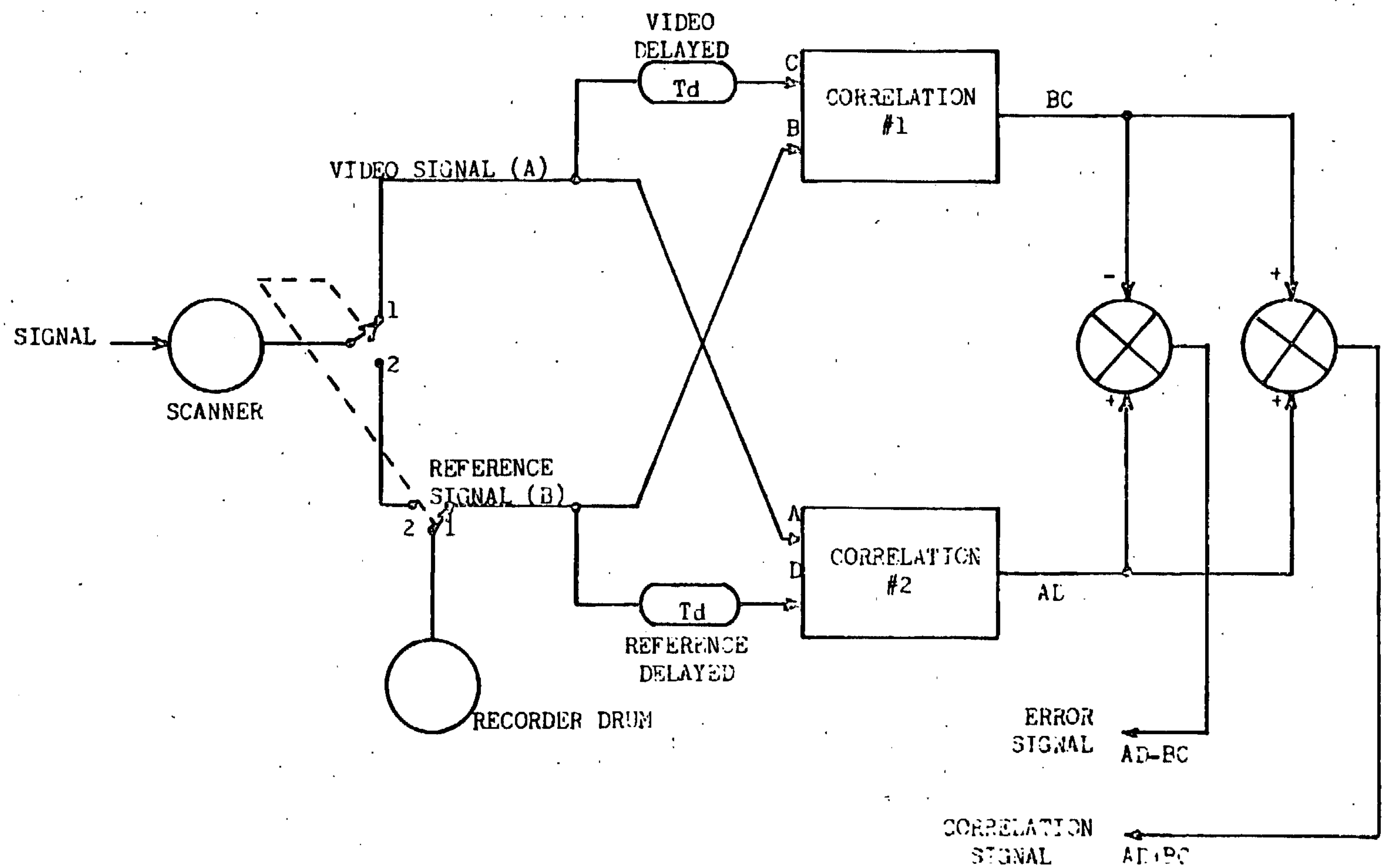



Figure 2-5. Block Diagram of V/H Sensor Signal Processing Circuitry

drum is on the inside of the scanner head). After a short time, the last recorded signal (Signal B - from a single rotation of the scanner) is held in memory on the drum. The next signal, from the next single rotation of the scanner, will be of exactly the same shape (that is, width of the quantized pulses) because no appreciable scene content change has occurred, but displaced in time by an amount proportional to the difference between the actual lens image velocity and the V/H tracking velocity. This second signal is called Signal A; the signal is processed with the switch set to position 1.

Signals A and B, both having a duration T, are then processed, producing an error signal which is used to correct the V/H tracking velocity. The development of the error signal is shown in Figure 2-6. In this figure, signals A and B are shown displaced by 5 microseconds. Signal C is generated by displacing signal A by 20 microseconds; signal D is signal B plus 20 microseconds.

In the processing circuitry, it is necessary to compare both the absolute displacement of A and B as well as the sign of the displacement (that is, leading or lagging). This is accomplished by generating signal AD, such that AD is present at the gate only when <u>both</u> A and D are high, and signal BC which is generated in the same manner. By way of summary, the signals are listed below.

| Signal | Pulse Duration (seconds) | Relative to A (microseconds) |
|---|---|---|
| A | T | Zero |
| B | T | t |
| C | T | + 20 |
| D | T | t + 20 |
| AD | T-(20+t) | t + 20 |
| BC | T-(20-t) | + 20 |

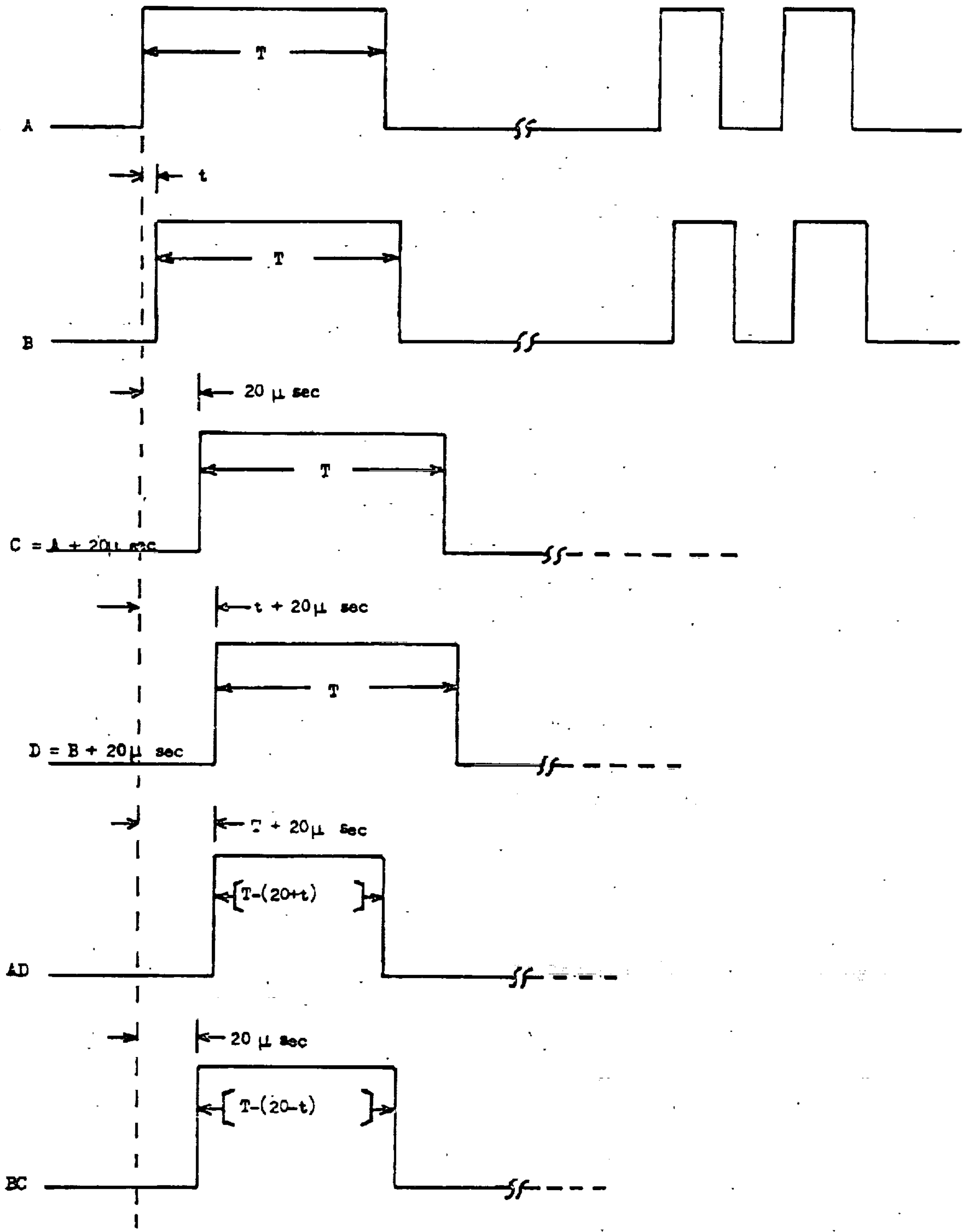



Figure 2-6. Error Signal Development

The width of signals AD and BC is thus a function of the parameter t, the amount that signal B leads or lags signal A. By subtracting signal BC from signal AD, both the magnitude and the polarity of the error (t) will be known. See Figure 2-7.

In addition to the error signal AD-BC, the processing circuitry generates the signal AD + BC, which is the correlation level. The correlation level must be great enough to indicate the presence of a good signal before the V/H tracking optics attempt to null the image velocity at the scanner.

The V/H error signal represents the sensor tracking rate error from both the yaw and thrust axes. This is the case because a scan of the sensor occupies a full circle (360 degrees), and because the scanner and memory drum are fixed with respect to the spacecraft. The memory drum is shown schematically in Figure 2-8. When the scanner output is from the upper and lower areas of the drum (in the figure these are clear), the detected motion is primarily in the thrust direction. When the scanner output is from the two side portions of the drum (dotted in the Figure), the detected motion is in the yaw direction. The thrust-axis error signal is used to crab the tracking mirror so that the image moves parallel to the spacecraft velocity vector (this reduces the yaw-axis error signal to zero). The amount of V/H crab necessary to reduce the yaw-axis error to zero is input to the spacecraft attitude control subsystem to correct the yaw orientation.

2.2.2.3 <u>V/H Instrumentation</u>. Flight Instrumentation - An analog output proportional to the mirror tracking velocity (or the V/H value) is telemetered to earth. This point is CTL-5. Through use of this output, it

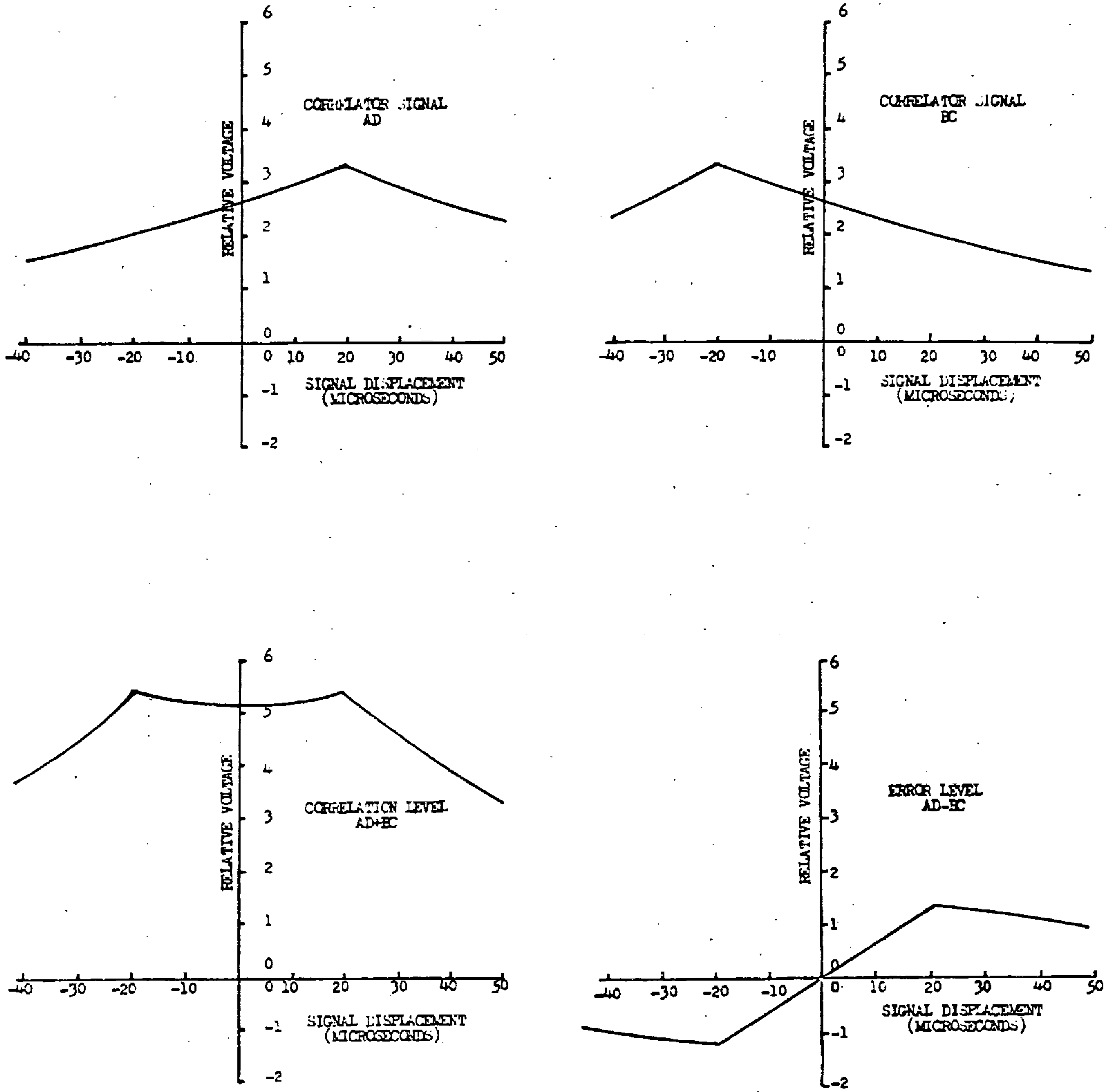



Figure 2-7. V/H Correlation Signals

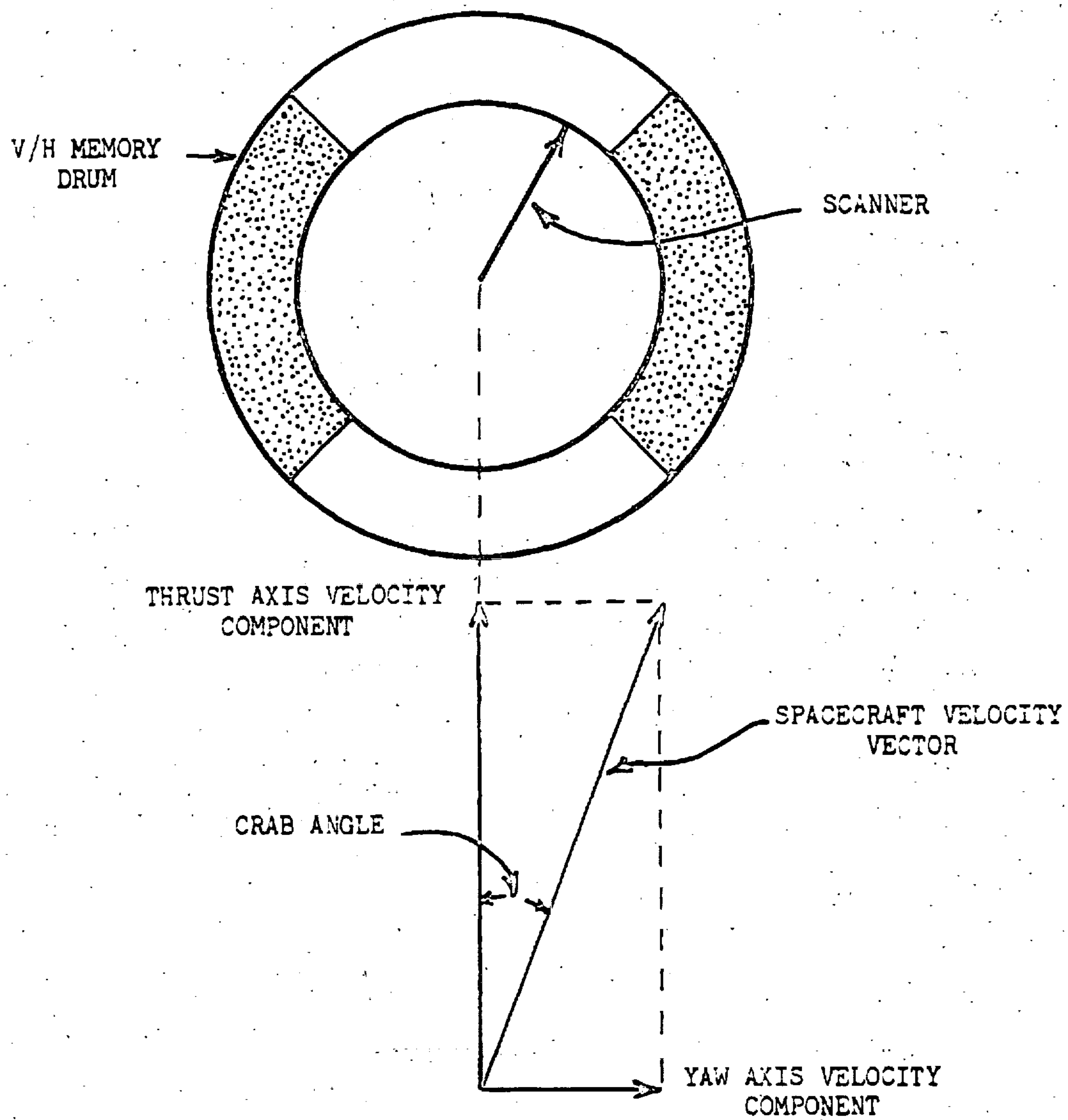



Figure 2-8. Memory Drum Schematic

is possible to monitor the actual V/H ratio present in the orbit. The V/H sensor output can then be compared with a calculated V/H ratio as determined from the spacecraft ephemeris if desired, to ensure that V/H sensor is operating correctly.

In addition to the V/H rate, the crab-error signal is transmitted to earth as telemetry output from the attitude control subsystem (Boeing Point No. AB06). This data can be used in conjunction with the output from the other attitude control subsystem sensors to manually align the spacecraft (that is, by ground command), if the V/H crab output is not used in the normal closed-loop mode.

Ground Test Instrumentation - For test purposes, the V/H information derived from the sensor can be overridden by inputs on the test point interface connector (these inputs are not available in flight). If a logic-1 voltage is presented at HLC-3 (V/H override command), and then an analog voltage (0 to 5 volts) is input at HLC-4 (programmed IMC command), the rate of V/H drive to the platen will be linearly proportional to the analog voltage at HLC-4. This procedure is used during ground tests.

The test point interface also monitors the output of the tach generator on the mirror servo system. Monitoring the output of this generator yields a more accurate value of V/H than is possible using CTL-5.

2.2.2.4 Functions Controlled by the V/H Sensor. The V/H output cam drives the 24-inch platen (and, indirectly, the 80-mm platen) at the correct IMC velocity. The sensor also provides a crab-error output, which can be used closed-loop with the attitude control subsystem to automatically correct any crab error, or open-loop via telemetry to manually (by ground command)

correct any crab error.

The V/H output cam also drives, through a 1:1 gear ratio, an encoder which is used with the CCP to provide switching signals to the camera (the encoder/electronics is called the V/H intervalometer). The functions controlled by the intervalometer are:

a. Draw vacuum and clamp film (24-inch and 80-mm platens)
b. 80-mm shutter actuation
c. Data lamps
d. 24-inch-shutter clutch release
e. Initiation of camera film advance (after exposure)

### 2.2.3 Camera

The PS camera contains two separate optical systems, one for high resolution and one for moderate resolution. The optical systems with their respective shutters and platens are discussed in the following paragraphs. See Figure 2-9 for a block diagram of the camera.

2.2.3.1 <u>High Resolution System.</u> Lens - The high resolution (one meter) lens is a six-element refractor. Each of the lens elements is polished to a spherical surface; however, zonal evaporation is used for the front surface of the first element of the lens to provide correction to a slight asphere. The lens is a 24-inch focal length, <u>f</u>/5.6 system with a half-field-angle of 10.4 degrees; the photographic frame produced is 219 x 55 mm. The depth of focus (for a maximum loss of 10 lines/mm) is approximately ±0.001 inch in the image plane.

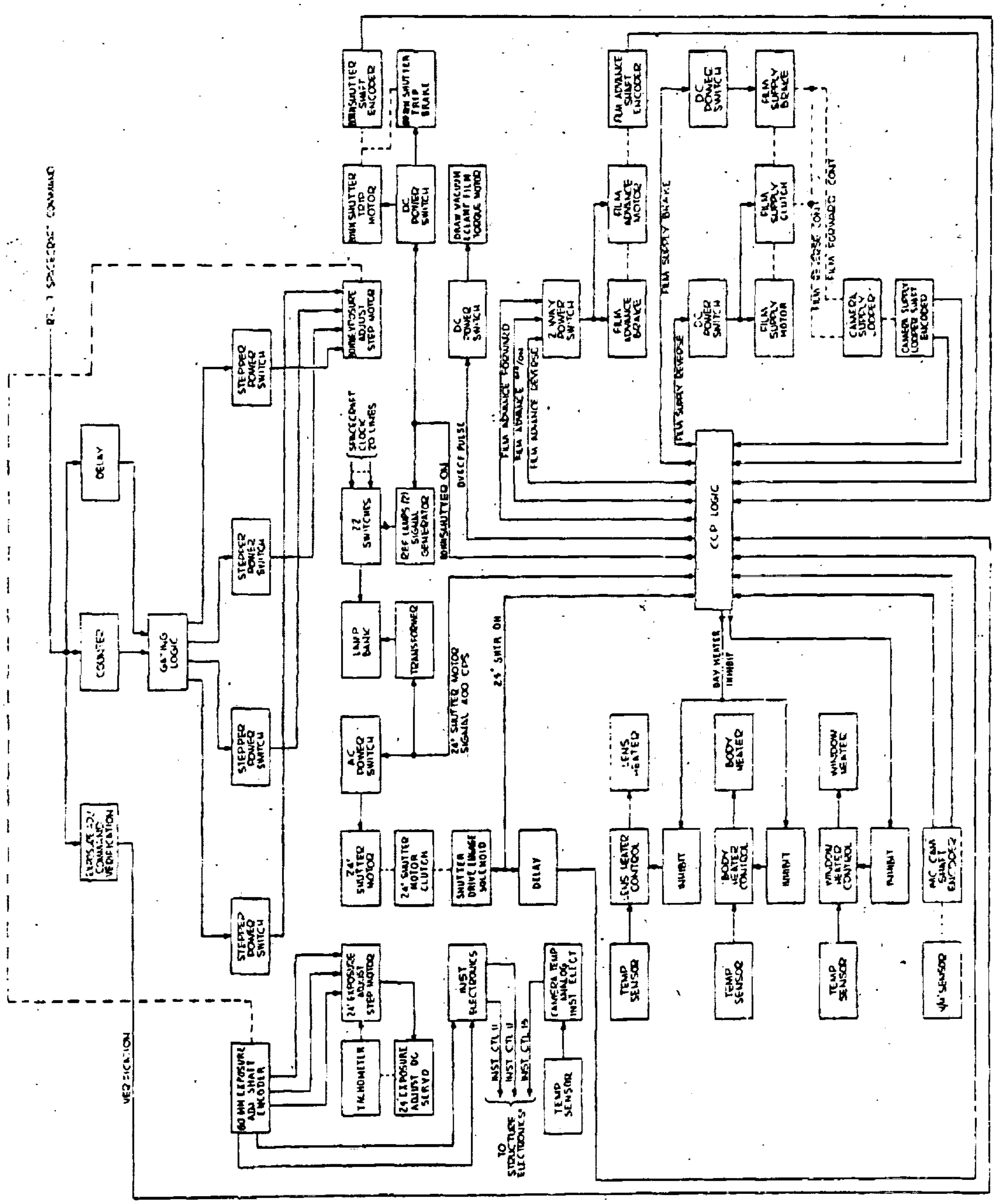


Figure 2-9. Camera Block Diagram

To achieve the required on-axis static resolution of 115 lines/mm, the optical elements are precisely figured, located, and mounted to prevent distortion of the lens surfaces. To ensure that the plane of best focus (PBF) remains within the ±0.001-inch depth of focus, careful attention was given to the lens mount and to the materials used in the lens components. Analysis of the lens shows that the thermal sensitivity remains well within the allowable limit, with the PBF shifting approximately 0.0007 inch per 10 F temperature change above or below the focus temperature. Figure 2-10 is a sketch of the lens elements as located in the lens barrel.

For exposure calculations, the lens f/number must be combined with the transmittance (t) to define the lens speed. Lens speed is stated in terms of a T-number which is defined as follows:

$$\text{T-number} = \frac{f/\text{number}}{\sqrt{t}}$$

Measurements of the transmittance of this system indicate that approximately 66 percent of the incident light in the 400- to 700-millimicron-wavelength range will be transmitted to the film plane (at the center of the field). Therefore:

$$\text{T-number} = \frac{5.6}{\sqrt{0.66}} = 6.90$$

The 24-inch lens has a circular field of view of ±10.4 degrees. However, due to restrictions on the width of the film available and the stringent weight requirements imposed on the PS, only a rectangular portion of the lens field is used for photography. The rectangular field measures ±10.2 degrees cross-track and ±2.6 degrees in-track.

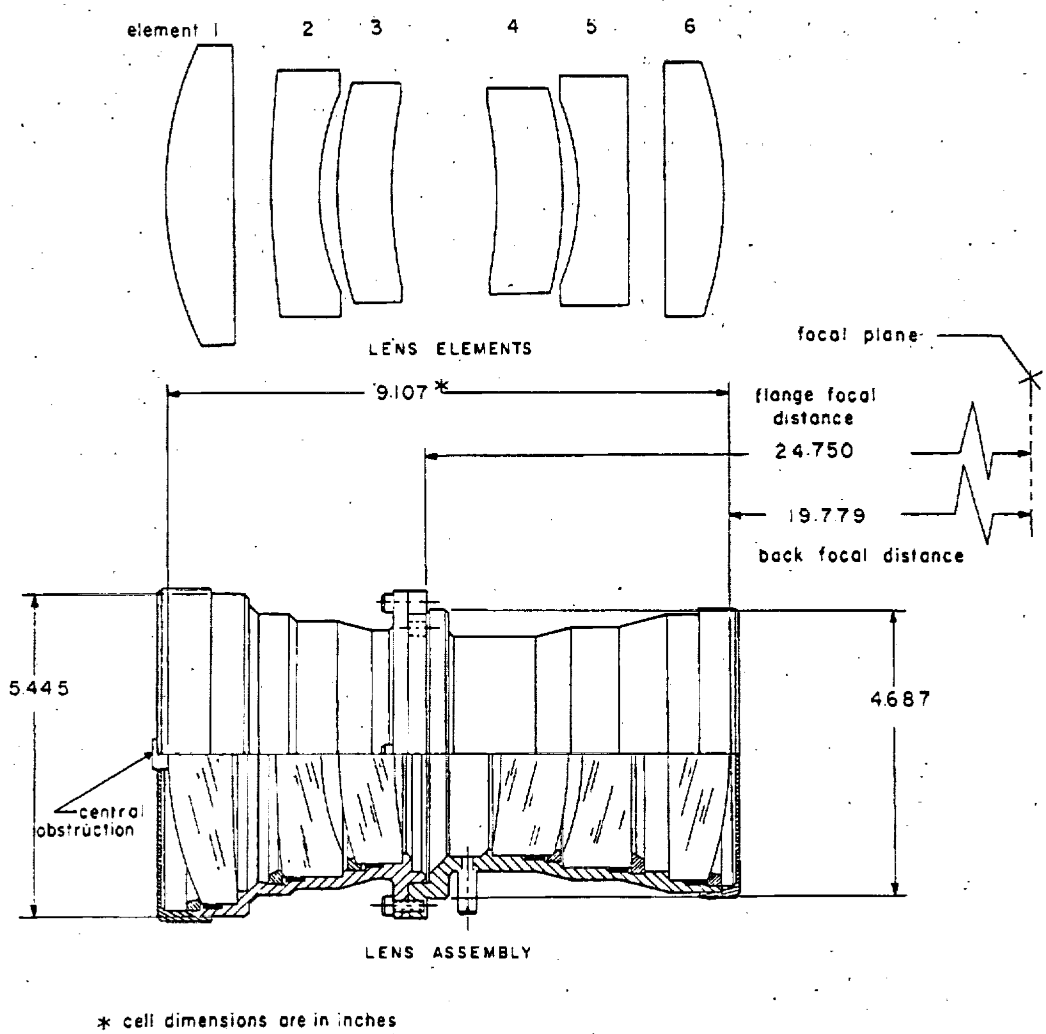



Figure 2-10. 24-Inch Lens Configuration

The 24-inch lens represents the optimum for this application. Theoretical studies conducted prior to designing the system were used to relate aperture, focal length, image smear, and film granularity to determine the optimum combination of aperture, focal length, and film type. The studies indicated that a 24-inch, f/5.6 lens with SO-243 film resulted in optimum resolution. The 24-inch, f/5.6 lens made by Pacific Optical Corp represented the best available off-the-shelf hardware for the PS. Any other lens/film combination having greater resolving power would have substantially exceeded the current 12-pound lens weight.

Platen - The high-resolution system photographs the lunar surface in discrete frames. For a framing camera of this type, the platen must perform two functions:

a. The film must be held tightly against the flat platen to coincide with the flat image plane produced by the lens.

b. The platen must move the film at the correct velocity to coincide with the image motion, providing IMC to reduce image smear to an acceptable level.

After unexposed film has been advanced across the platen, the platen clamps the edges of the film mechanically. When mechanical clamp has been completed, a bellows draws a partial vacuum through small holes and channels in the platen surface. The partial vacuum holds the film tightly against the platen, producing a flat film plane. The mechanical clamp/vacuum draw sequence is initiated by either a control pulse from the V/H sensor or from the 0.4 cps generator if the V/H sensor is OFF. The mechanical clamp/vacuum draw sequence continues for a total of from 0.44 to 2.79 seconds depending on the V/H rate if the V/H sensor is ON, or for 0.625 seconds if the V/H sensor is OFF. During this time, exposure of the film takes place. When the mechanical clamp/vacuum draw sequence is complete, the platen releases the film and the film-advance motor removes the exposed film from the platen by drawing 11.7 inches of film through the camera.

During the exposure, the platen moves the clamped film at the correct velocity to minimize image smear. The platen is driven by the V/H sensor output cam, with the total travel distance being approximately 0.3 inch. The V/H linkage is such that the platen cycles continuously at the correct velocity whenever the V/H sensor is turned ON. Film clamping and vacuum draw are then programmed at the correct time within the platen cycle.

The shutter assembly is attached to the camera structure in front of the 24-inch platen. The operation of the shutter is discussed below.

Shutter - The 24-inch shutter is a constant-velocity variable-slit focal- plane shutter and is contained in the platen assembly. The shutter consists of two curtains which are each stretched between two rollers. Exposure takes place when the edge of the first curtain moves across the width of the film, with the edge of the second curtain following the first at a precise distance. Because the curtain velocity is constant, varying the distance between the two curtains produces a change in the exposure time.

For this shutter, slit widths (or curtain separations) of 2, 1, and 1/2 inch can be selected by command. These slit widths result in exposure times of 1/25, 1/50 and 1/100 second, respectively.

The shutter curtain-to-film spacing is 0.500 inch, producing a minimum shutter efficiency of 84 percent, based on a 24-inch, f/5.6 lens. The shutter is capable of completing each cycle (forward motion and return) in 0.100 second and cycles at a maximum rate of one operation per 1.6 seconds.

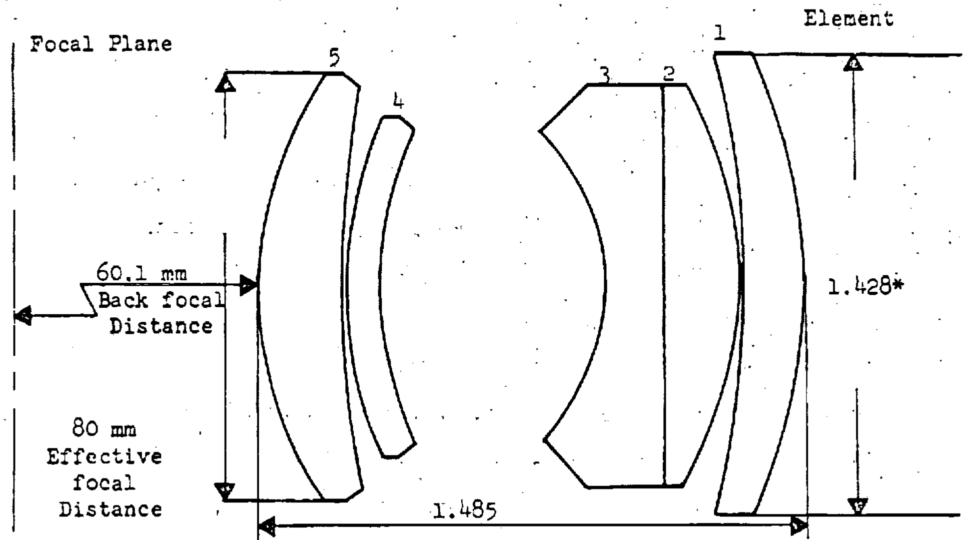
Operation of the shutter is started by a solenoid releasing the screen rollers; the rollers then rotate at a precise velocity produced by springs within the roller spindles. At the same time, a kicker spring assembly accelerates the shutter-return motor shaft, bringing the motor shaft to the correct velocity. When the exposure has been completed, the motor returns the screens, torquing the spindle springs and re-setting the kicker assembly for the next actuation. During the shutter return portion of the cycle, the screens overlap, preventing a second exposure of the film. Between cycles, the shutter is closed and lighttight.

2.2.3.2 Moderate Resolution System.

Lens - The moderate resolution (eight meter) lens is a commercial Schneider Xenotar six-element refractor. The lens is an 80-mm focal length, $f/2.8$ system with a half-field angle of 28 degrees. To improve resolution, the lens is stopped down to $f/5.6$. The lens exposes a rectangular film format of 65 x 55 mm. The depth of focus is approximately ±0.002 inches for a maximum resolution loss of 15 lines/mm. See Figure 2-11 for a drawing of the lens elements and assembly.

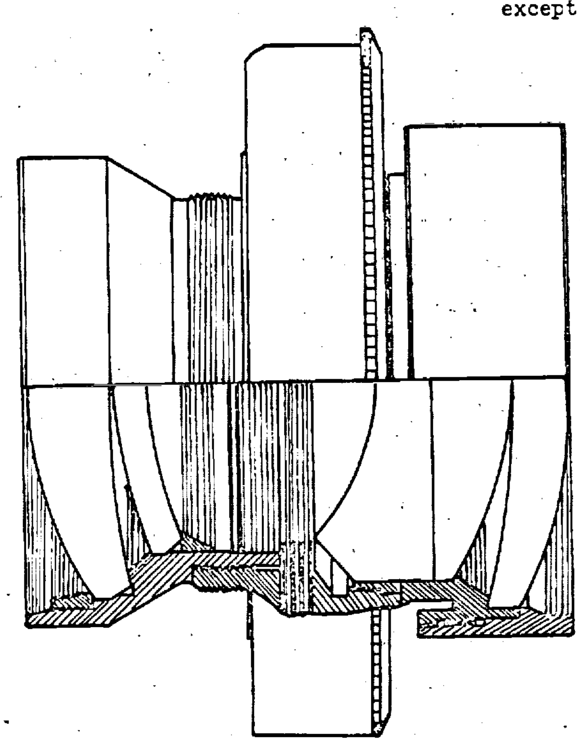
The axial transmittance of the 80-mm lens over the 400- to 700-millimicron-wave-length range averages approximately 92 percent, for a T-number of 5.75.

Platen - The 80-mm platen assembly performs the same functions as the 24-inch platen. The vacuum draw/clamping and IMC functions are identical to those of the 24-inch platen. However, due to the short focal length of this lens, the IMC velocity and platen travel distance are reduced by a factor of 7.6 (610 mm divided by 80 mm). The 80-mm platen is coupled to the 24-inch platen by a lever arm which drives the platen at the reduced IMC velocity required for the 80-mm lens.




LENS ELEMENTS

* All dimensions in inches except where noted



LENS ASSEMBLY

Figure 2-11. 80mm Schneider Xenotar Lens

Shutter - The 80-mm lens uses a between-the-lens leaf shutter, of the same type as those used in high quality commercial cameras, to expose the film. The shutter is activated by a small motor and provides exposure times of 1/25, 1/50 and 1/100 second. The motor runs for 0.200 seconds and both activates and re-sets the shutter during this time.

2.2.3.3 Camera Electronics. The camera electronics acts as an interface between the CCP and the camera operational functions. This is necessary because the CCP cannot directly control the relatively high current levels present in many of the camera components. The camera electronics consists primarily of switches which control the operation of the following camera components:

a. Clamp motor
b. Supply rewind motor
c. Film advance motor
d. Supply clutch
e. 80-mm shutter motor
f. 24-inch shutter motor
g. Film supply brake
h. Data lamps

In addition, the camera electronics provides a counter and a decoder to operate the exposure selector.

### 2.2.4 Film Handling System

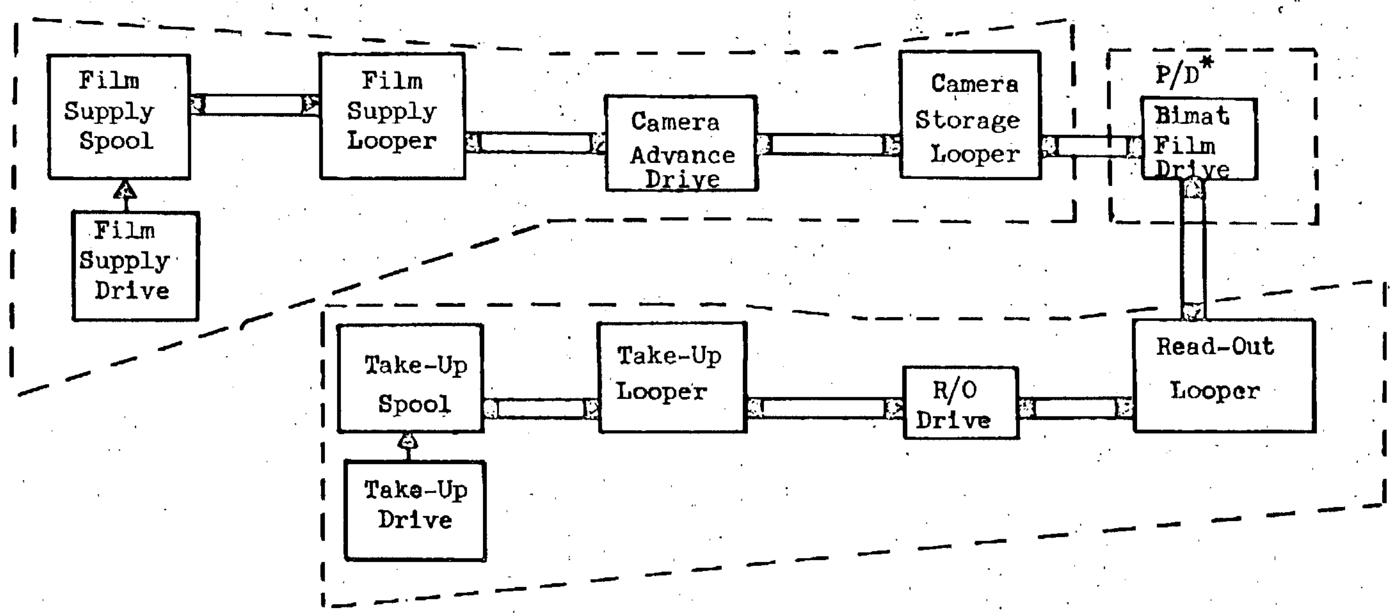
The function of the film handling system (FHS) is to transport and store the photographic film during certain PS operational modes. The FHS transports film in two directions, forward and reverse. During the photographic, processing, and wind-forward modes, the FHS transports film in the forward direction (toward the take-up). During quick-look read-out and final read-out modes, the FHS transports film in the reverse direction (toward the supply).

The FHS contains the following components:

a. Film-supply drive
b. Film-supply spool
c. Film-supply looper
d. Camera-advance drive
e. Camera-storage looper
f. Bimat-drive/processor-dryer
g. Read-out looper
h. Read-out drive
i. Take-up looper
j. Take-up spool
k. Take-up drive
l. Film leader

Figure 2-12 shows the logical orientation of these components in the system. The dashed blocks are not considered part of the FHS but are the PS sections through which the film is transported. A picture of these components mounted on a test set is shown in paragraph 2.7.

2.2.4.1 <u>Component Description.</u> The operation of each component in the film handling system is described in this paragraph. The CCP signals which control the various FHS components are given; however, no attempt is made to identify




*P/D Processor/Dryer

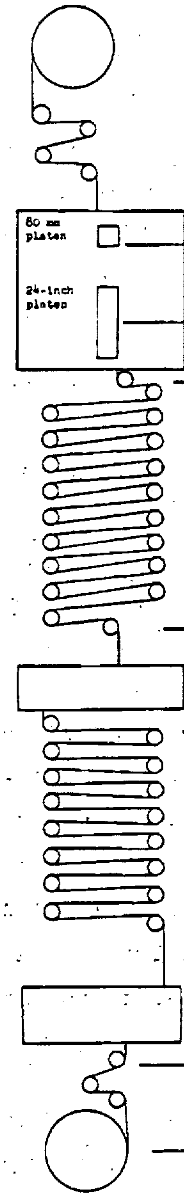
Figure 2-12. Film Handling System Components

each of the necessary PS logic conditions for a specific CCP response. The complete PS logic diagrams and equations are included in paragraph 2.5. Figure 2-13 is a diagram of the film handling threadup.

2.2.4.1.1 Film-Supply Drive. The film-supply motor drives the supply spool through a gear train and electrical clutch mechanism. The 28-v d-c motor operates the FHS in the reverse direction only and is turned on by control signal CAS-13 from the CCP. The drive mechanism is capable of emptying the film-supply looper at a minimum rate of 3 inches-per-minute (see paragraph 2.2.4.1.3).

2.2.4.1.2 Film-Supply Spool. The film-supply spool originally contains the unexposed film. The supply spool also receives and stores the exposed and processed film during the final read-out mode. This spool is enclosed by a radiation-protection shield. The film capacity of the spool is 260 feet. The spool contains an electromagnetic brake which keeps the film tightly wound except during camera film advance when the supply looper draws film out with the spool brake released. This brake is controlled by the CCP control signal CAS-12.

2.2.4.1.3 Film-Supply Looper. The film-supply looper is attached to the film-supply spool housing and acts as a film storage buffer between the supply spool and the camera-advance drive. The looper contains three rollers; the two outside rollers are fixed and the middle roller is attached to a pivot arm. When film is supplied to the looper, a spring on the pivot arm exerts tension causing the middle roller to move away from the plane of the two fixed rollers. A driving force greater than the spring tension will pull film from the looper, drawing the middle roller toward the plane of the two fixed rollers.




| | | | File Length (Inches) |
|---|---|---|---|
| Supply spool to 80-mm platen ℄ | | | |
| (Supply looper electrically full-spool full) | | = | 13.507* |
| Supply looper electrically empty | | = | 11.587 |
| 80-mm platen ℄ to 24-inch platen ℄ | | = | 17.283* |
| 24-inch platen ℄ to Storage Looper | | = | 15.852* |
| Camera storage looper = | Electrically empty | = | 56.250* |
| | Electrically full | = | 304.250 |
| | Mechanically empty | = | 51.250 |
| | Mechanically full | = | 309.250 |
| | Electrical Capacity | = | 248.000 |
| Storage looper to processor via twister | | = | 15.065* |
| Processor/dryer | | = | 63.667* |
| Processor/dryer to R/O looper via twister | | = | 9.805* |
| Read-out looper | Electrically full | = | 79.643 |
| | Electrically empty | = | 31.643 |
| | Mechanically full | = | 83.143 |
| | Mechanically empty | = | 28.143* |
| | Electrical Capacity | = | 48.000 |
| Read-out looper to optical mechanical scanner | | = | 7.807* |
| Optical mechanical scanner | | = | 8.000* |
| Optical mechanical scanner to take-up spool | | | |
| (Take-up looper electrically full-spool empty) | | = | 11.320* |
| Take-up looper electrically empty | | = | 8.820 |

String up length at launch = 247.0 inches
(total of numbers marked *)

Note: At launch the supply looper is electrically full, the storage looper is electrically empty, the read-out looper is mechanically empty and the take-up looper is in a random position. Take-up looper has been assumed to be full for launch condition total.

Figure 2-13. Film Handling System Thread-Up.

The maximum mechanical film capacity of this looper is 3.5 inches in excess of the minimum thread-up length. The looper spring exerts a nominal film tension of 1.5 pounds. The looper is capable of pulling in and delivering 11.69 ±3 inches of film-per-second.

The looper has an encoder with two segments which provide supply-looper empty (SLE) and supply-looper full (SLF) indications. SLE occurs when the looper contains one-half inch of film or less. SLF occurs when the looper contains two inches of film or more. In the forward film direction, SLF is one of the PS logic conditions which control the supply-spool brake. In the reverse film direction, SLE, SLF and other CCP logic control the film-supply motor.

2.2.4.1.4 Camera-Advance Drive. The drive is powered by a 28-v d-c reversible motor with a gear system and a metering-roller mechanism. The CCP control signal CAS-1 sets the motor for forward operation; CAS-1 keys a delayed control signal CAS-5 which turns the motor ON. CAS-5 also releases the drive brake; the drive then advances film through the camera. The rate of advance is 297 mm/sec (or one frame-per-second). A metering roller accurately measures the quantity of film being pulled through the camera by the drive. When one frame of film has passed the metering roller, an encoder coupled to the roller sends a signal (EOS) to the CCP which switches the motor OFF.

In the reverse direction, the control signal CAS-7 sets the camera-advance drive for reverse operation. CAS-7 keys the delayed control signal CAS-5 to turn the camera-advance drive ON. The drive then pulls film from the camera-storage looper and/or the read-out looper.

Supply looper full (SLF) is a logic condition to turn the reverse operation OFF and supply looper empty (SLE) is a logic condition to resume operation. Camera storage and read-out loopers empty (CLE and RLE, see below) terminate the reverse operation. During active read-out after Bimat clear the advance

drive is inhibited to conserve power. At the end of each read-out operation (during final read-out) the advance drive cycles film into the supply looper at the same rate as the forward advance rate until CLE and RLE are reached. Before Bimat clear there is no reverse film movement (other than from the take-up to the read-out loopers).

2.2.4.1.5 Camera-Storage Looper. The looper is a storage buffer between the camera-advance drive and the processor-dryer. The looper has nine rollers on a fixed carriage, and nine corresponding rollers on a moveable carriage. The two roller carriages are mechanically connected by the carriage guide shafts. Film is looped back and forth around corresponding roller pairs in the two carriages. A negator spring exerts a constant tension, tending to pull the two roller carriages apart. When film is supplied to the looper, the spring tension pulls the roller groups apart, drawing film into the looper.

The total mechanical film capacity of the looper is approximately 258 inches or 22 frames. The looper contents, in a range of 0 - 21.5 feet, are monitored by a gear-driven potentiometer and converted to a 0 - 5-v d-c analog signal. The negator spring in this looper exerts a constant film tension of 1.75 pounds regardless of the quantity of film in the looper. The looper accepts film from the camera drive at a rate of 11.7 inches-per-second and delivers film to the processor-dryer at a rate of 0 to 75 inches-per-minute.

There is a two-segment encoder switch in the camera-storage looper. One segment indicates a camera looper full (CLF) condition; the other indicates a camera looper empty (CLE) condition.

CLF occurs when 237 inches of film are in the looper; this condition will turn the camera memory OFF, terminating the photographic mode after the advance of the film in the exposure cycle under way at the time of CLF. CLE occurs when 5 inches of film or less are in the looper; CLE will turn the Bimat drive OFF

in the processing mode. It will also turn the take-up drive OFF in the wind-forward mode (after Bimat clear) and terminate reverse camera-advance drive after each complete read-out operation.

2.2.4.1.6 Bimat Drive. The Bimat drive operates in the forward direction only, and advances the photographic film from the camera-storage looper through the processor-dryer entirely by friction contact between the photographic and Bimat films. The 80-v (peak-to-peak) 400-cps motor drives the Bimat processing film positively by needle-like spikes imbedded in the drive roller. The drive advances both the exposed photographic film through the processor/dryer and the Bimat processing film within the processor at a rate of 2.4 inches-per-minute. The drive is activated by MS-13 and MS-14 motor signals from the CCP. When a Bimat clear (BMC) condition exists (after Bimat has been cut and removed from the system), the Bimat drive cannot again be enabled. Then film can be pulled through the processor/dryer in either direction because the processor and dryer drums are free wheeling.

2.2.4.1.7 Read-Out Looper. The looper is a storage buffer between the processor/dryer and read-out dryer. During processing the looper takes up film from the processor/dryer. During the quick-look and final read-out modes, the looper pulls in film from the read-out drive.

The looper operates mechanically in the same manner as the camera-storage looper. There are eight roller pairs in the two carriages. Film is pulled in via a negator spring and pulled out by either the take-up drive or the reversed camera-advance drive, depending on the operational mode. The looper operates in the same manner as discussed in paragraph 2.2.4.1.5 (camera-storage looper)

The maximum mechanical film capacity of this looper is 55 inches. The film content is monitored by a potentiometer which produces a 0 to 5-v d-c analog signal. A negator spring in this looper exerts a constant film tension of 2.0 pounds.

The read-out looper has a 3 segment encoder which indicates three film-storage conditions. Read-out looper empty (RLE) occurs when about 3.5 inches of film or less are in the looper. Read-out looper partial full (RLP) occurs when approximately 5.5 inches of film or more are in the looper (this is a near empty looper condition). Read-out looper full (RLF) occurs when about 48 inches of film (four frames) are in the looper.

RLE and RLP control the take-up motor forward operation in the PS processing mode. The motor is OFF until RLP turns it ON, and remains ON until RLE turns it OFF. RLE is also a condition for turning the take-up drive OFF in the PS wind-forward mode and is a condition for turning the camera-advance drive OFF in the final read-out mode. RLF will terminate the quick-look read-out mode, but it has no effect on the read-out during the PS final read-out mode.

2.2.4.1.8 Read-Out Drive. This drive is an 80-v (peak-to-peak) two phase 400-cycle, synchronous motor with a gear-clutch-cam mechanism. The drive performs several functions.

During both quick-look and final read-out modes, the processed film is moved continuously at a measured rate in the reverse direction by means of a geared-metering roller. Three cam-driven operations take place: (1) a high precision cylindrical cam moves the scanning lens across the film (2) a simple cam operates the film clamp so that focus is obtained (with respect to the OMS lens), and (3) a simple cam step advances film in the read-out gate at the end of each scan.

The motor is turned ON when motor signals MS-5 and MS-6 are supplied from the CCP to the read-out control electronics power-switch circuitry. During a scan of a framelet, the metering roller slowly draws film out of a loop on the read-

out looper side of the read-out gate and continuously feeds the read-out looper. See Figure 2-14. The roller in this looper is connected by a lever to a similar roller and loop on the take-up side of the read-out gate. As film is drawn out of the output loop the lever transmits the force and the input loop is enlarged and draws film at the same steady rate out of the film take-up assembly. Between these loops the film clamp holds the film section being scanned stationary in the read-out gate. When the end of the scan (or scanning lens turn-around) is reached, the cam operated gate opens and the lever between the loops is cam driven to move film in step fashion through the gate. The film clamp recloses and scan resumes back across the film. The cams are all two cycle to accomplish back and forth scan operation. The metering roller supplies an accurate 0.100 inch of film in each framelet. The sequence continues moving the scanning lens back and forth across the film and advancing the film through the read-out system until the command RTC-6 (read-out drive OFF) or other PS inhibiting logic occurs.

Attached to the cam is a two segment encoder switch whose logic indicates two positions of the optical-mechanical scanner. The spot-stop (SPS) condition indicates that the OMS is positioned at its farthest excursion on the pre-exposed, calibration side of the film where the film clamp is released. When the read-out is commanded OFF, the drive mechanism will continue until it arrives at the spot-stop position. Then SPS will turn the drive motor OFF. During PS modes where film travels in the forward direction through the read-out gate, the read-out drive-motor clutch is disengaged by control signal CAS-11. With the clutch disengaged and the clamp released, film free-wheels through the OMS.

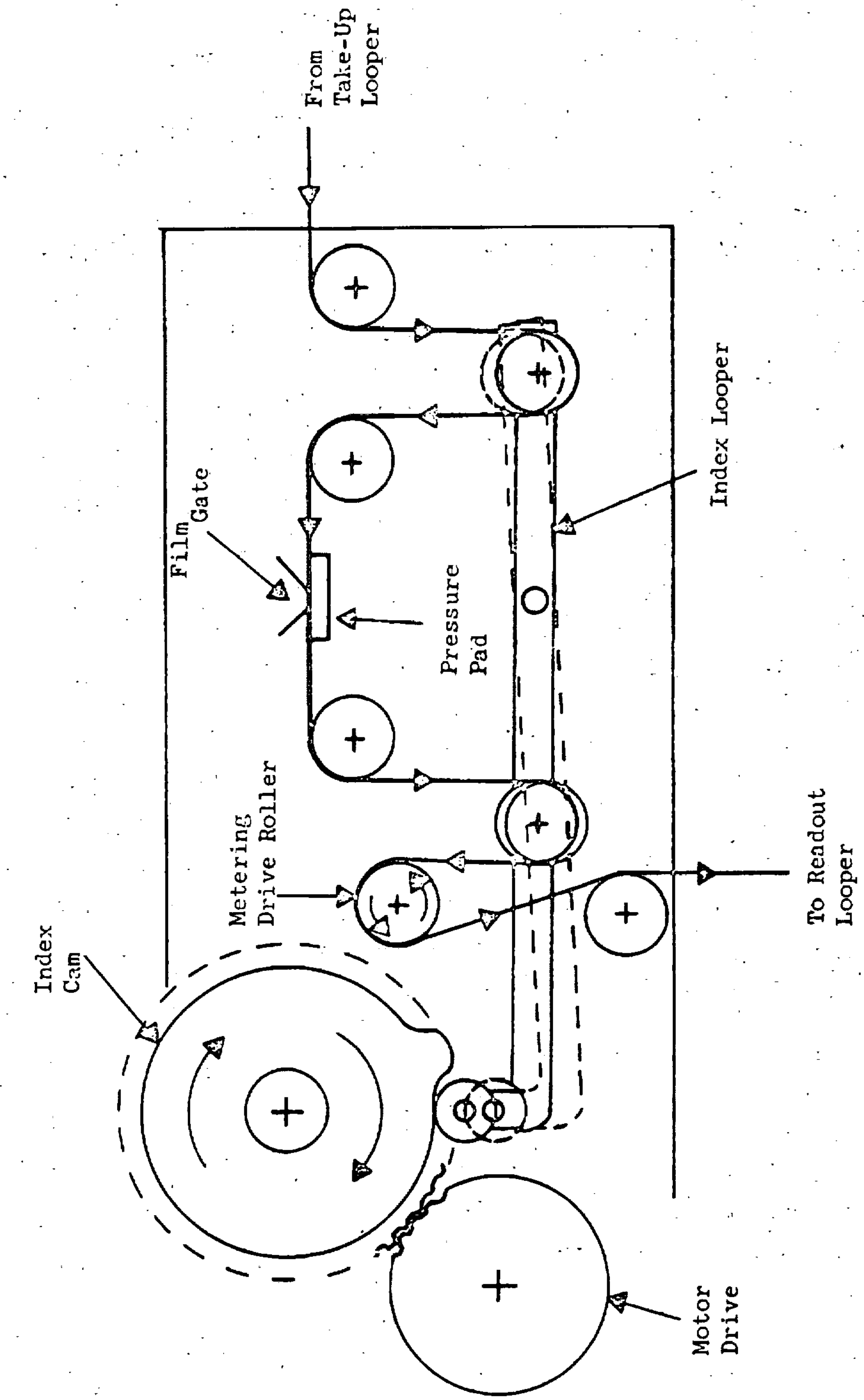



Figure 2-14. OMS Film Advance Mechanism

The other encoder segment generates a focus-stop (FSS) signal. This signal indicates that the OMS is positioned over the pre-exposed portion of the film clamped in the read-out gate. When the read-out drive is commanded ON the first time, the OMS will leave the spot-stop position and move the short distance to the focus-stop position, where FSS will turn the drive OFF. This allows the scan line to be focused and the photovideo gain to be adjusted on pre-exposed lines in the film by real-time commands. After the read-out drive has been turned ON a second time by a ground command, read-out scanning is continuous and FSS will not turn the optical-mechanical scanner OFF during subsequent passes over the focus-stop position. Focus and gain can be subsequently checked without turning the read-out OFF by an SPC-3 command (read-out electronics ON) whereupon the OMS will go to FSS position and stop until RTC-5 is again transmitted.

2.2.4.1.9 Take-up Looper. The looper is a film storage buffer between the read-out system and the take-up spool. It functions mechanically in a manner similar to the film supply looper. In the forward film direction, film is pulled through this looper by the take-up drive. It performs no storage function and its contents are indeterminate depending on system friction and film flexibility. In the reverse direction this looper takes in film driven out of the take-up spool by the take-up drive motor.

The maximum mechanical film capacity of this looper is 3.5 inches in excess of the minimum length for thread-up. The nominal film tension exerted by the spring in the looper is 2.8 pounds.

The looper contains a two segment encoder switch. The take-up looper empty (TLE) condition occurs on one segment when 0.375 inch of film or less is in the looper. The take-up looper full (TLF) condition occurs on the other

segment when 2.5 inches of film or more are in the looper. The encoder conditions control the take-up drive during the PS read-out modes. TLF will turn the take-up drive OFF; TLE will turn the drive ON.

2.2.4.1.10 Take-Up Spool. The spool receives and stores film while the film handling system is operating in the forward direction. In the reverse-film direction, it supplies film to the take-up looper. The film capacity of this spool is 260 feet. The film content is monitored by a gear-driven potentiometer which produces a 0 to 5 v d-c analog signal.

2.2.4.1.11 Take-up Drive. This drive is a reversible 28 v d-c motor which is coupled to the take-up spool through a worm gear. It is capable of pulling film onto the take-up spool at a rate of 0.3 to 75 inches-per-minute. (The wide velocity variation is due to variations in the various looper duty cycles.) It is also capable of driving film off of the take-up spool into the take-up looper at a rate of 0.3 to 75 inches-per-minute. The gear system is always engaged and provides the necessary braking action for the take-up spool.

Control signal CAS-14 sets the motor for forward operation; CAS-15 sets the take-up motor for reverse operation. CAS-16 turns the motor ON and OFF.

2.2.4.1.12 Film Thread-up Length and Twisters. Figure 2-13 is a thread-up drawing of the film handling system. It shows the film length within and between components.

Also shown are the looper electrical and mechanical capacities (lengths of film). The minimum thread-up length of a looper is equivalent to the mechanical empty length. The total thread-up length at launch is 247 inches.

Because of payload space requirements, two twisters are used to change the plane of the film. One twister changes the film plane by 90 degrees before the film enters the processor dryer; the other twister changes the film plane another 90 degrees after the film leaves the processor dryer.

A change of film direction is accomplished by rollers on the twisters. These rollers are designed for minimum frictional force and support the film in such a way that there is no danger of the film tearing as it passes through the twisters.

2.2.4.2 Operation of the Film Handling System. A functional description of the various film handling modes of operation follows. A particular film handling mode occurs for a particular PS operating mode. Not all PS modes have a film handling mode.

There are six basic film handling modes, four in the forward direction and two in the reverse direction:

a. Film advance during photography
b. Wind-up on take-up spool during processing
c. Wind-up on take-up spool after quick-look read-out
d. Wind-up on take-up spool after final read-out

Reverse direction:

a. Unwind from take-up spool during quick-look and final read-out
b. Wind-up on supply spool during final read-out

These modes are discussed as follows:

a. Film Advance During Photography. In this mode the film handling system advances an unexposed frame into the camera and an exposed frame out of the camera. This operation begins when the camera-advance drive is turned on and the camera-advance brake is simultaneously released. This drive pulls film from the supply looper. When the supply looper becomes not full the supply spool brake is released. Film is pulled from the supply spool into the supply looper by the looper tension. Film enters the

looper faster than the camera-advance drive removes it. When the supply looper becomes full, the supply spool brake is engaged, and the camera-advance drive continues. The full-not full cycle is repeated several times until one frame or 11.69 inches of film have been advanced. Then the camera-advance drive is turned off. The film driven out of the camera is taken in by the camera storage looper. The remainder of the film handling system is not active during this mode.

b. <u>Wind-up on Take-up Spool During Processing.</u> During processing, the film handling mechanism transports the film from the processor dryer to the take-up spool where the film is wound up. Film leaves the processor/dryer at a rate of 2.4 inches-per-minute, and is pulled into the read-out looper by the looper tension. Even though the take-up looper exerts a film tension differential of 0.8 pound with respect to the read-out looper, the frictional forces in the passive read-out system reduce the differential to approximately zero. Therefore, film begins to accumulate in the read-out looper. When 2 to 3.5 inches of film in excess of electrical empty have been pulled into this looper, the partial-full encoder signal turns the take-up motor ON in the forward direction. The encoder-electrical empty signal provides logic to turn the motor OFF. This cycle repeats whenever the read-out looper film content reaches 2 to 3.5 inches in excess of electrical empty and if no other inhibiting logic is present.

c. <u>Wind-up on Take-up Spool after Quick-Look Read-Out.</u> After quick-look read-out, up to 4 frames are stored in the read-out looper. An RTC-16 (wind-forward) command sets the Bimat-drive motor enable and switches the film handling system to the forward direction. If processing is not inhibited, it also releases the read-out drive clutch by setting the read-out release memory. The take-up motor is then turned ON and pulls film from the read-out looper, through the read-out system and take-up looper, and on to the take-up spool. When the read-out looper is empty the take-up motor is turned OFF.

d. <u>Unwind from the Take-up Spool for Quick Look Read-Out.</u> In this mode, film on the take-up spool is driven through the read-out system into the read-out looper. The remainder of the FHS is inactive. When the read-out drive ON command (RTC-5) is given, the take-up looper fills and the read-out drive pulls film out of the take-up looper at approximately 0.3 inch-per-minute. Film driven through the read-out gate is pulled into the read-out looper by the looper tension.

When the take-up looper becomes empty, the reversed take-up drive is turned ON and drives the film out of the spool into the looper. The take-up looper pulls in the film; and when it becomes full, the take-up drive turns OFF. This cycle repeats itself as the read-out drive continues pulling film from the take-up looper. If the 4 frame capacity of the read-out looper should be reached, the electrical full signal turns the read-out OFF. Other PS logic can inhibit read-out prior to this time.

e. <u>Wind-up on Supply Spool During Final Read-Out.</u> During this mode, film is transported from the take-up spool, through the entire FHS, and wound on the supply spool.

When the read-out drive is commanded ON the take-up drive operates in reverse until the take-up looper reaches electrical full. The read-out drive pulls film from the take-up looper. When the take-up looper reaches electrical empty, the take-up drive turns ON in reverse and fills the looper, turning OFF at electrical full. The take-up drive and looper continue to cycle until the read-out drive is turned OFF. The film from the read-out is taken up and stored in the read-out looper. In a normal PS mission, since the read-out advance rate is slow (0.3 inch-per-minute) the read-out looper will never reach full before solar eclipse occurs.

However, under test conditions the read-out may continue to fill the read-out looper until it is mechanically full (unless turned OFF by read-out drive OFF). Further read-out operation (if permitted) would supply film for take-up and storage in the camera-storage looper since the processor-dryer is free wheeling and looper tension exceeds the friction. A full camera-storage looper is an extremely improbable circumstance and no logic provision exists.

At the read-out turn-off, provided solar eclipse does not occur so soon as to inhibit FHS operation, the camera film-advance drive is enabled in reverse and it pulls film from the camera-storage and read-out loopers. The supply looper takes up the film until it becomes full. This condition turns the camera drive OFF, releases the supply-spool brake and turns ON the supply drive. This drive pulls film from the supply looper onto the supply spool. When the supply looper is empty, the supply drive turns OFF, the supply brake is engaged, and the camera drive is turned ON. This pulls film from the camera-storage and read-out loopers. When these loopers are empty the camera drive is turned OFF.

f. <u>Wind-up on Take-up Spool after Final Read-Out (Wind-Forward Mode).</u> During the final read-out mode film is run backwards through the system onto the film supply spool. If it is desired to read out the photography a second time, the film is transported from the film-supply spool to the take-up spool (see paragraph e). This mode can occur only after Bimat film has been cleared and the processor/dryer has become passive. This mode is initiated by SPC 26 through 31 commands to obtain the desired program and by an SPC-2 (camera ON) command. This command releases the read-out drive clutch (sets the read-out release memory) and supply spool brake, and turns ON the camera-advance drive. If the camera-storage and read-out loopers are not empty the take-up drive will turn ON. When the supply-spool brake is released, the supply looper fills; then the supply-spool brake is engaged again. The camera-advance drive pulls film from the supply looper and reduces its contents to less than full. This causes

the supply-spool brake to be released, and allows the supply looper to fill again. This cycle continues until the end of the program as the camera-advance drive pulls film at a rate of one frame every 2.3 seconds or 9.2 seconds depending on the camera-framing rate selected (because the V/H sensor is OFF, camera-advance signals are generated by a multivibrator in the CCP (see paragraph 2.3.1); the film is taken up by the camera-storage looper. When the camera-storage looper becomes not-empty, the take-up drive is turned ON. This drive pulls film from the camera-storage looper, through the remainder of the FHS, and on to the take-up spool. If a camera storage looper full condition should occur, the camera-advance drive is turned OFF; however, the take-up drive continues pulling film from the camera-storage looper. If this mode is to be continued, another SPC-2 command has to be sent to restart the cycle after the camera-storage looper contents are less-than-full. A series of SPC-2 commands are required to advance the desired number of rewind frames.

### 2.2.5 Processor/Dryer

The processor dryer (P/D) is designed to develop, fix, and dry the Type SO-243 Film after photography. The film is thus prepared for read-out (and, incidentally, is no longer susceptible to radiation damage). The P/D consists of the following components:

a. Bimat film
b. Processor (drum, heater, heater controller)
c. Dryer (drum, heater, heater controller)
d. Bimat supply reel
e. Bimat take-up reel
f. Bimat drive
g. Bimat cutter (roller, logic elements, electronics)
h. P/D structure
i. Diffusion channels
j. Dry Bimat condition sensor
k. Bimat clear sensor

A block diagram of the P/D is given in Figure 2-15.

2.2.5.1 <u>Operation of the P/D.</u> Operation of the P/D begins when the CCP signal BME (Bimat motor enable) is given. This signal is dependent on several PS logic conditions (see paragraphs 2.3 and 2.5); processing starts automatically when these PS conditions exist (for example, exposed film must be stored in the camera storage looper before processing can begin). Upon receipt of BME, power is applied to the Bimat drive motor. Bimat film and photographic film (from the camera storage looper) are advanced through the processor. Processing of the photographic film begins when it is laminated with the Bimat film in the processor. The processing continues as the two films pass around the processor drum, which is maintained at 85 F by a thermostatically controlled resistance heater. Processing ends when the two films have traveled 310 degrees around the drum together; a processing time of 3.4 minutes. The film and Bimat are then separated by the P/D; the Bimat is spooled onto the Bimat take-up reel, and the film continues into the dryer portion of the P/D.

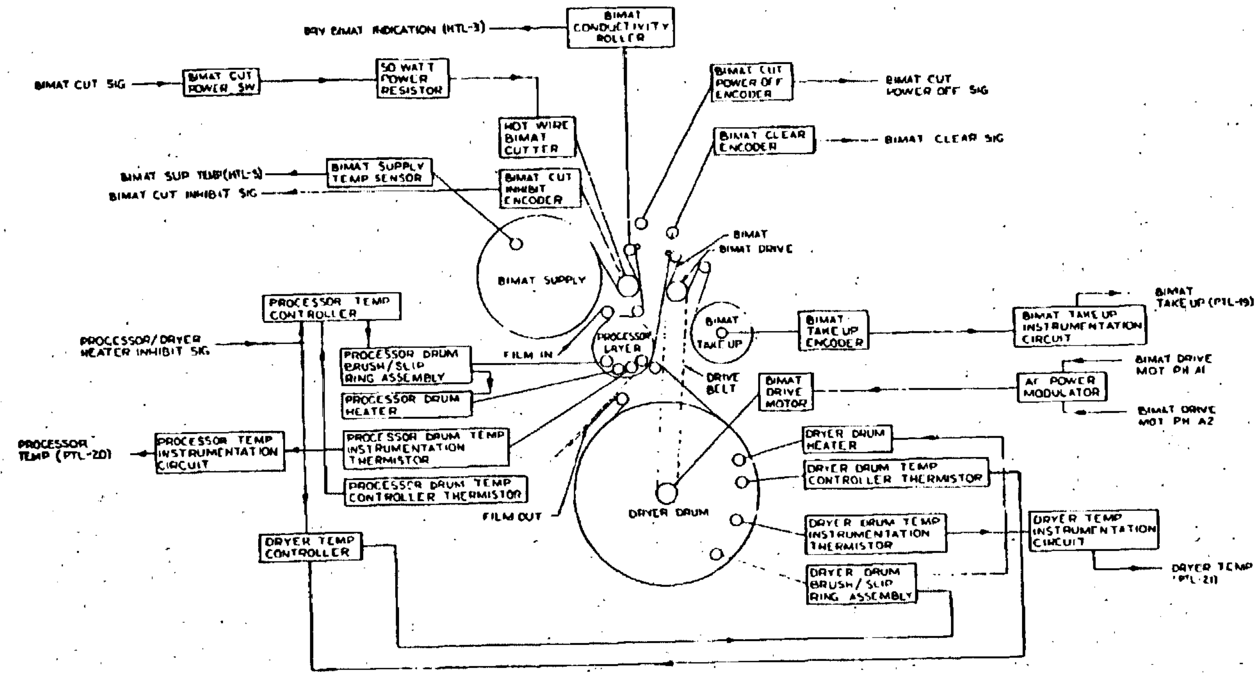



Figure 2-15. Processor/Dryer Block Diagram

The Type SO-243 film is wrapped approximately 300 degrees around the dryer drum; any one point on the film contacts the drum for approximately 11.4 minutes. The drum is maintained at a temperature of 95 F using a combination of thermostatically controlled resistance heaters and heat from the Bimat drive motor. As the film is dried, the resulting moisture is absorbed by potassium thiocynate crystals held in pads inside the P/D casing. These crystals maintain relative humidity inside the unit at 50 ± 20 percent. After the drying process is complete, the film leaves the dryer and passes into the read-out looper which takes in approximately 3-inches of the dried film, until the RLP switch is actuated. The take-up motor is turned on by the RLP signal, and removes the film from the read-out looper. See paragraphs 2.3, 2.2.4, and 2.5.

When the photographic portion of the mission has ended, the remaining Bimat can be cut and removed from the film path to permit the processed SO-243 to run backwards through the system during the final read-out mode (or the Bimat can be completely run out, being wound onto the Bimat take-up spool, thus clearing the system.

Bimat cut takes place when power is applied to a resistance wire heater located in a groove in the Bimat-cut roller. When power is applied to the wire, it becomes red hot, expands out of the groove and severs the Bimat. (An encoder is used to avoid the application of power to the wire when the Bimat and groove are about to separate and a catastrophic partial cut could be made.) When the Bimat has been cut, the Bimat take-up motor continues to operate, pulling film into the take-up reel until the Bimat clear sensor indicates that the Bimat has been removed from the system. When complete, the Bimat take-up motor turns OFF and all power to the P/D is permanently inhibited. The P/D then becomes passive, and free wheeling, so photographic film can be pulled in either the forward or reverse direction through the unit.

2.2.5.2 Major P/D Components

2.2.5.2.1 Bimat Film. The Bimat film is KODAK BIMAT Film (Ester Base), Type SO-111. The Bimat consists of a 0.004-inch-thick polyster film support carrying a hydrophilic gelatin layer which contains the processing solution. For a description of the Bimat development process, see paragraph 2.2.8.2.

2.2.5.2.2 Processor. The processor laminates the Type SO-243 Film with the Bimat, holds the two together for the required length of time, and separates them when processing is complete.

Film is advanced through the processor by frictional contact between the film and the Bimat (which is, in turn, driven by the Bimat drive motor).

The processor consists of a cylindrical 3-inch-diameter processing drum, an internal drum resistance heater with sliding electrical contacts, temperature control electronics, and a temperature monitoring telemetry point. These are housed in a cylindrical compartment. The drum rotates freely and contains the heater. The temperature control and monitoring electronics are in the electronics assembly outside of the film enclosure.

The processing time is 3.4 minutes. The processor temperature is maintained at 85 ± 2.5 F during processing. The drum temperature in a range of 40 to 100 F is converted to a 0 to 5-volt d-c analog signal. This information is obtained at telemetry point PTL-20.

2.2.5.2.3 Dryer.

The dryer provides the necessary time and temperature to dry the processed film. This component consists of a drying drum (on which the film is wound), an internal drum resistance heater, with sliding electrical contacts, temperature control and monitoring electronics (located in the electronics assembly outside of the film enclosure), and humidity pads. The 9-inch-diameter drum is not driven but rotates freely as the processed film passes

through the system. Humidity pads are located on the inside wall of the dryer compartment.

The photographic film is wrapped approximately 310 degrees around the dryer drum. The drying time is approximately 11.4 minutes. The temperature is maintained at 95 ± 5 F by a thermistor controlled heater. Some heat is supplied by the Bimat drive motor. The humidity pads absorb most of the moisture evaporated from the film. A d-c analog signal ( 0 to 5 volts), proportional to dryer temperature from 40 to 140 F, is telemetered via PTL-21.

2.2.5.2.4 <u>Bimat Supply Reel.</u> The supply spool stores 230 feet of Bimat film before it is used for processing the photographic film. The temperature within the supply spool is 60 ± 10 F and is passively maintained by thermal insulating materials and surface coatings.

The Bimat supply spool incorporates padded flanges minimizing the evaporation of the developing fluid from the Bimat film and preventing edge dryout prior to use.

2.2.5.2.5 <u>Bimat Film Take-Up Spool.</u> The spool accepts and stores up to 230 feet of Bimat film after the film has been used for processing. The spool is rotated by the Bimat drive motor through a belt-gear roller mechanism.

The rotation of the Bimat film take-up spool is instrumented (PTL-19) to indicate a train of digital 1 logic pulses at a repetition rate of 1 to 4 pulses per two minutes. Non-rotation of the spool is indicated by a lack of pulses.

2.2.5.2.6 Bimat Film Drive  The drive advances the Bimat film from the supply spool to the take-up spool during processing. The friction resulting from lamination of the Bimat film and the photographic film in the processor also allows the drive to advance the photographic film in the processor/dryer.

The drive motor is an 80-volt peak-to-peak 400-cycle synchronous motor. It is located centrally in the dryer drum. The motor shaft is connected by a timing belt and gears to the Bimat drive roller. In addition to the Bimat drive roller, the belt also rotates a rubber roller which contacts the rim of the take-up reel, with a variable contact pressure, causing it to take-up the Bimat as required. A closed-loop, tension sensing device controls the application of power to the take-up reel, to match the velocity of the Bimat produced by the Bimat drive roller. When the Bimat drive motor is turned on by CCP signals MS-13 and MS-14, Bimat film is pulled into the Bimat take-up spool by the rotation of the Bimat drive roller and the take-up spool. As the spool fills, the wrap-diameter of the spool increases. This action causes the film to be pulled into the spool at an increasing rate. Before the film enters the spool it passes around a tension roller which is connected by a lever arm to the shaft with the rubber drive roller. A spring holds the drive roller against the take-up reel rim. Tension in the take-up forces the roller away from the reel against the spring and causes a reduction in the force driving the take-up reel. In this manner the Bimat film-advance rate remains nearly constant.

2.2.5.2.7 Bimat Cutter. The cutter is designed to sever the Bimat film by means of a heated wire. The wire is recessed in a groove along the length of the Bimat cut roller. A Bimat power inhibit (BCI) encoder is coupled to the roller ensuring a correct roller position for film cutting. When the cut Bimat command is given (RTC-8), the Bimat advances and turns the roller until ($\overline{\text{BCI}}$) is present. Voltage is then

applied to the cutting wire. Current through the wire heats the wire red-hot and expands it up out the groove so that contact is made with the film. The film is severed within five seconds after power is applied to the heater wire, but this can be up to one minute after the Bimat cut command is given. After the film has been severed, the end of the film is pulled past another sensor, the Bimat-cut power off (BCO) encoder. The encoder senses that the film has been cut and shuts off the power to the cutting wire. The encoder signal with the Bimat clear signal (BMC) permanently inhibits the processor/dryer heaters, the Bimat cutter, and the Bimat drive.

2.2.5.2.8 Bimat Clear Sensor. The sensor is designed to detect that the Bimat film has cleared the processor; a necessity before the PS final read-out mode can be initiated.

The sensor is an encoder located in the Bimat film take-up compartment. After the Bimat film has been cut and the film has cleared the processor and the sensor, the encoder segment opens, causing a Bimat Clear signal (BMC) to be sent to the CCP. BMC with the Bimat-cut power OFF signal (BCO) permanently inhibits any further processor-dryer operation. Bimat clear (BCI) indication is monitored by telemetry point PTL-18.

2.2.5.2.9 Dry Bimat Condition Sensor. The Bimat film is threaded-up sometime (relatively soon) before launch. The first part of the Bimat film roll is dry with the dry section of Bimat in contact with the thread-up photographic film in the processor; an indefinite time can elapse without permanent lamination of the film and Bimat taking place in the processor. A ground instrumentation point is provided to verify whether the PS is in a launch configuration, i.e., only dry Bimat is contacting the film. The sensor is located in the Bimat supply-spool

compartment. It senses a dry or wet condition by measuring the film conductivity. The sensor is HTL-3, and is read out via hardline only.

2.2.5.2.10 P/D Structure. The processor-dryer structure provides the necessary mounting surfaces for the P/D components. Because of the temperature and humidity control requirements on the other PS components, the structure is designed to retain moisture and isolate the other PS components from processing and drying heat. The Bimat film supply, the processor, the Bimat film take-up, and the dryer are housed in separate compartments. Film enters and leaves these compartments through narrow slots in the walls of the compartment. Film passes between the compartments through long narrow diffusion channels.

Epoxy fiber glass, coated with vacuum deposited aluminum, is used to house the processor-dryer components. The primary structural base support is made of aluminum. These materials meet the processor-dryer thermal, weight, and strength requirements.

2.2.5.2.11 Diffusion Channels. Diffusion channels are used to connect the various compartments within the P/D. Film passes through these channels as the processing/drying cycle takes place. These channels minimize the rate of moisture loss from the Bimat supply (to prevent edge dry-out) and reduce moisture dispersion in and out of the P/D.

2.2.5.3 Encoder Signals. These signals are sent to the CCP which controls the logical operation of the Processor/Dryer. The logic signals are determined by open-close switch conditions taken from encoder segments. An open segment sends a $6.5 \pm 1.0$ v d-c signal to the CCP and indicates a logic one. A closed switch reduces the signal to the CCP and indicates $0 {}^{+1.0}_{-0.3}$ volts, and indicates a logic zero.

There are four encoders in the processor/dryer. The Bimat-cut power inhibit (BCI) encoder determines when the Bimat-cut roller is in the correct position for cutting the Bimat film. The Bimat-cut power off (BCO) encoder causes power to be removed from the Bimat cutter after cutting has been completed. The Bimat-clear (BMC) encoder signals that the Bimat film has cleared the processor after Bimat cutting has occurred. The Bimat take-up encoder provides a train of on-off signals indicating that the Bimat take-up spool is operating normally.

2.2.5.4 Telemetry Outputs. There are five conditions or events in the processor/dryer which are telemetered. Telemetry point PTL-19 changes state to indicate whether the Bimat take-up spool is rotating. Telemetry point PTL-22 verifies the Bimat cut command. Telemetry point PTL-18 indicates whether the Bimat film has cleared the processor after it has been cut. PTL-20 indicates the processor temperatures. PTL-21 indicates the dryer temperature. Section 5.0 is a list of the ranges and accuracies of these points.

### 2.2.6 Read-Out Group

In the read-out group, the processed film is scanned by a high-intensity spot of light. The light intensity variations, which result from the light passing through the density variations of the film, are converted to a time-varying electrical signal by a photo-multiplier tube. This signal is then input to the communications subsystem in the spacecraft for transmission to the earth. The read-out group is composed of seven major elements which are discussed in the following paragraphs.

2.2.6.1 Line Scan Tube. The line scan tube (LST) serves as a source of light in the flying-spot scanning system used in the PS. The light is produced by a focussed electron beam (emitted from a cathode) which is accelerated by a screen grid and strikes a rotating phosphor-coated drum anode. The electron beam excites the phosphor, producing an intense spot of light. The electron beam is swept back and forth linearly across the surface of the anode at 800 cps, with the beam being "blanked" during the return sweep. The anode is rotated at about 1300 rpm whenever the LST is ON, to prevent phosphor burn at the high intensity levels required for this application. The anode rotation is accomplished by mounting the rotor of an a-c motor to the anode shaft inside the sealed LST glass envelope with the stator located outside of the envelope. The output of the LST appears visually as a bright line of light across the width of the anode; in reality, the line is a single spot moving across the anode at an 800 cps rate. (See Figure 2-16).

The sweep and sync electronics is designed to operate with the LST to sweep and blank the electron beam as it moves back and forth across the LST anode.

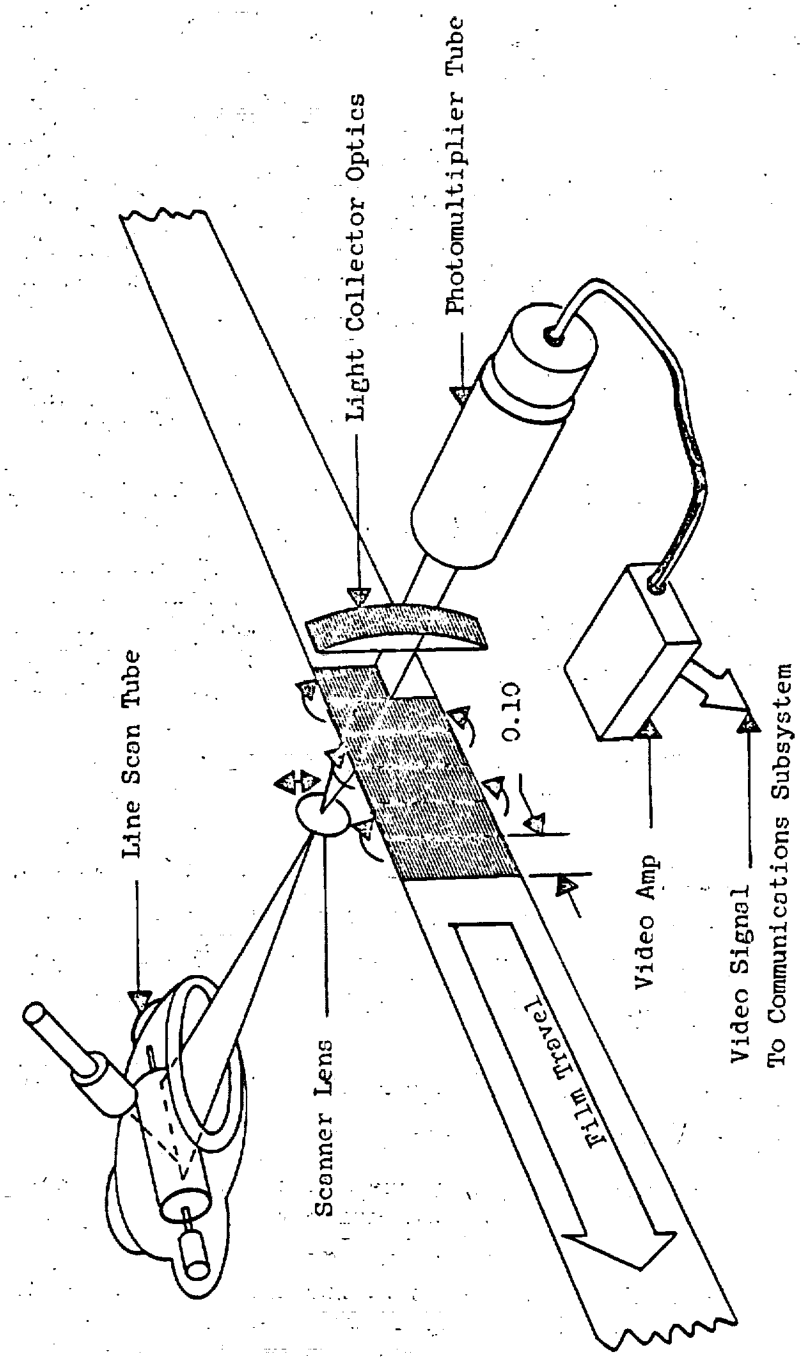



Figure 2-16. Read-Out Process

2.2.6.2 Sweep and Sync Electronics (S & SE). The S & SE performs the following functions:

a. Provides a linear ramp (sawtooth waveform) of deflection current to the LST deflection yoke to move the scanning spot at a uniform velocity across the rotating anode at an 800 cps rate. The active sweep requires approximately 1160 micro-seconds; sweep return is accomplished (with the beam blanked) in approximately 90 micro-seconds.

b. Provides a blanking pulse train to the LST control grid to blank the electron beam during the retrace period.

c. Provides sync signals to the video amplifier, used in generating the composite video signal.

d. Provides electrical control of spot centering (horizontal and vertical), horizontal size, and brightness to the LST. Horizontal centering and size, and vertical centering of the spot are controlled by adjusting the S & SE during the read-out alignment procedure.

e. Provides control of LST focus through the use of real time commands during the mission.

2.2.6.3 High Voltage Supply. The high voltage supply has outputs of 20,000 and 1000 v dc for an input voltage range of 27.5 to 30.5 v dc. The supply is used to provide power to the LST anode (20,000 volts) and to the LST screen grid (1,000 volts).

2.2.6.4 Read-Out Control Electronics. The read-out control electronics performs the following functions:

a. Provides two phase a-c optical-mechanical scanner power to the OMS drive motor (400 cps) and to the anode motor on the LST (50 cps).

b. Controls the operation and direction of rotation of the take-up motor.

c. Controls the operation of the read-out drive clutch.

The read-out control electronics performs these functions in response to control signals and 400- and 50-cycle input signals from the CCP.

2.2.6.5 <u>Reference Frequency Generator.</u> The reference frequency generator provides an 800 cps ±0.01 percent symmetrical square-wave signal to the CCP. (The CCP counts-down the 800 cps input to provide 400-cps and 50-cps signals to the read-out control electronics). The read-out control electronics amplifies these signals and supplies them to the OMS, and the LST anode motors.

2.2.6.6 <u>Optical - Mechanical Scanner (OMS).</u> The OMS images the LST output and mechanically scans the processed film.

During read-out, the OMS mechanism clamps the film in the read-out gate. Simultaneously, the OMS moves a lens across the width of the film, while the image of the LST spot produced by the lens at the film plane moves back and forth for a distance of 0.105 inches (see Figure 2-16). Scan is thus accomplished in two directions; optically, via the LST and the lens, parallel to the long dimension of the film, and mechanically, via the OMS mechanism, which moves the lens across the film.

The lens carriage is driven and returned across the film by a drum cam, which is, in turn, driven by the 400 cps OMS drive motor. The drum cam also initiates the film advance and clamp functions which take place during the turn-around period of the lens carriage. One revolution of the cam results in two scans, and two film advances of 0.100 inches each. The film is read out for both directions of the lens carriage, and this results in an A frame and a B frame. (These are specially handled in final photographic reassembly to preserve the correspondence of images in the two frames).

The OMS requires 20.02 ± 0.10 seconds to traverse 2.2690 ± 0.0002 inches across the width of the film. In the turn-around region, the film is unclamped, advanced, and reclamped in 2.00 ± 0.01 seconds. The film advance distance is 0.100 ± 0.001 inch. The scan-line image on the film must be within 0.0005 inch from the position corresponding to perfect mechanical scan linearity.

2.2.6.7 Photo Video Chain. The photo video chain receives the modulated light energy produced by passage of the flying spot through a negative image on the film and produces a corresponding video signal output from a photo-multiplier tube. The video amplifier amplifies the PM tube output and adds the sync pulses received from the sweep and sync electronics to produce the composite video signal. The composite video signal is then input to the communications subsystem for transmission to the earth. The photo video chain consists of the four major components discussed below. (See Figure 2-17 for a block diagram of the photo video chain).

a. Photomultiplier Tube - When the flying spot has been imaged on the processed film by the OMS lens, a portion of the incident light passes through the film and is modulated by the density variations of the film. The modulated light is then input to a photomultiplier tube, which converts the modulated light input to an electrical signal at the photocathode and amplifies the cathode current by a factor of more than $10^3$.

b. Video Amplifier - The electrical output from the photomultiplier tube is input to the video amplifier. The video amplifier amplifies the signal and adds synchronization pulses to form the composite video signal. The video amplifier produces two video signal outputs, one for a ground test line, and the other for the spacecraft video data link. In addition, the amplifier produces a rectified video signal instrumentation output.

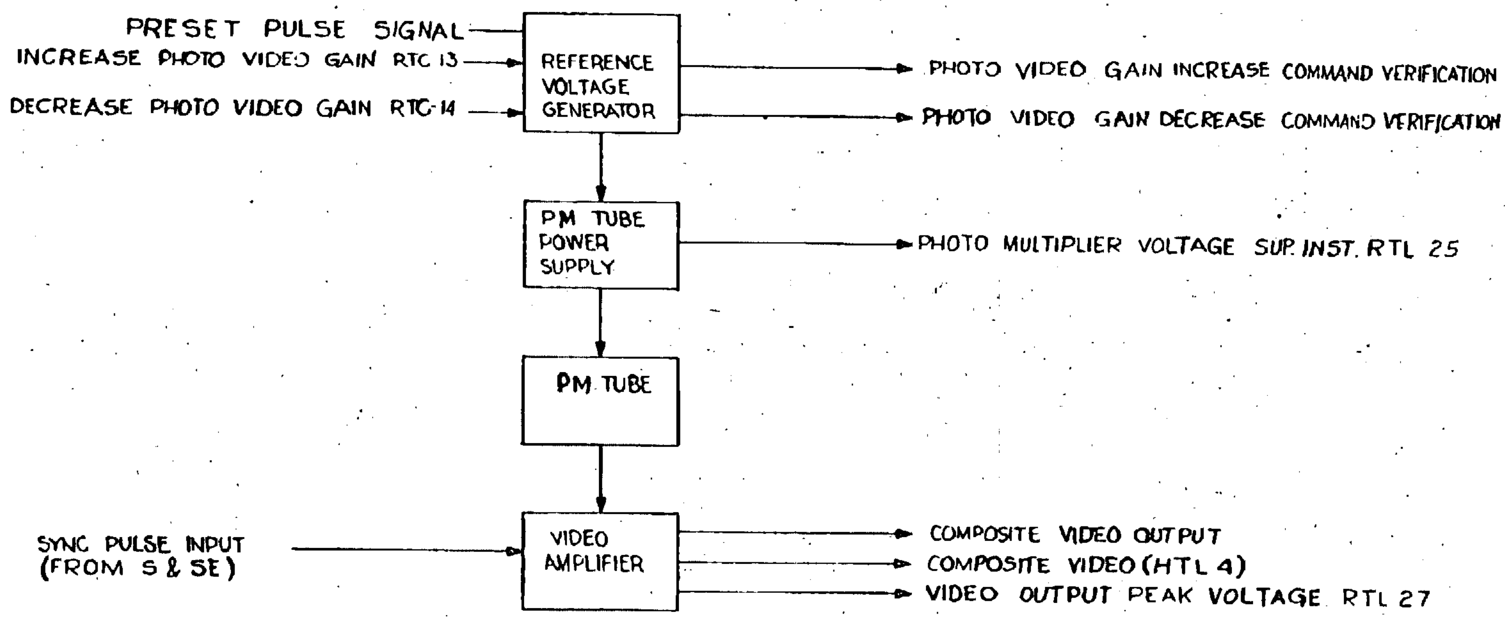
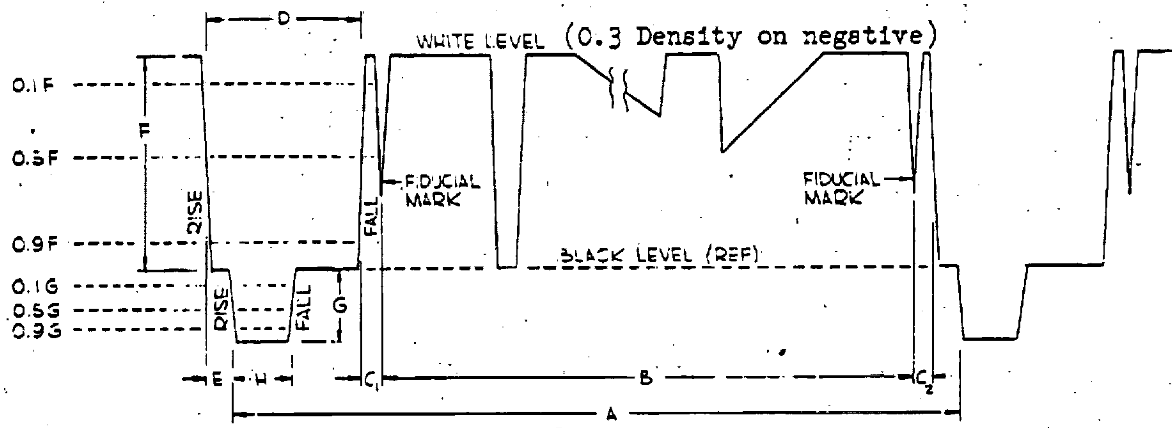



Figure 2-17. Photo Video Chain Block Diagram

The composite video signal is the output of the photo video chain. This signal includes blanking (produced by the absence of LST light during retrace) and synchronizing pulses in addition to the video signal, and provides a d-c-restored black reference level to the communications subsystem at the interface. (See Figure 2-18 for a sketch of the waveform).

c. Reference Voltage Generator - The reference voltage generator provides a negative d-c reference voltage which is used for control of the photomultiplier-supply output voltage. The reference voltage can be adjusted in 16 incremental voltage changes in response to command signals. This process adjusts the photo video gain in increments of approximately 7 percent of nominal through voltage changes to the photomultiplier-tube anode, and is used to optimize the performance of the read-out group.

d. Photomultiplier Power Supply - The photomultiplier power supply provides electrical power to the photomultiplier anode and dynodes, enabling the photomultiplier tube to operate. As discussed in paragraph c. above, the photomultiplier supply is controlled by the reference voltage generator, to adjust the gain of the photomultiplier tube.




| ITEM | DIMENSION | DESCRIPTION | UNITS | OUTPUT PS |
|---|---|---|---|---|
| 1 | A | AVERAGE PERIOD OF SCAN | μSEC | 1250 ± 0.12 |
| 1.1<br>1.1.1<br>1.1.2 | | JITTER<br>SCAN LINE TO SCAN LINE (ADJACENT)<br>PEAK TO PEAK WITHIN A 23 SECOND PERIOD | μSEC | <br>+0.4<br>+0.6 |
| 2 | B | ACTIVE SCAN TIME, TIME BETWEEN FIDUCIAL MARKS | μSEC | 1105 ± 11 |
| 3 | $C_1$ & $C_2$ | OVERSCAN OF FIDUCIAL MARKS | μSEC | $C_1$ $C_2$ WITHIN 7 μSEC |
| 4 | D | BLANKING SIGNAL WIDTH (MEASURED AT 50% AMPLITUDE) | μSEC | 50 ± 4 |
| 5 | E | FRONT PORCH (MEASURED AT 50% AMPLITUDE OF BLANK & SYNC) | μSEC | 23 ± 5 |
| 6 | F | PEAK WHITE AMPLITUDE (CORRESPONDING TO 0.3 FILM DENSITY) | V (P) | 5 ± 0.2 |
| 7 | G | SYNC PULSE AMPLITUDE | V (PP) | 0.9 ± 0.1 |
| 8 | H | SYNC PULSE WIDTH (MEASURED AT 50% SYNC PULSE AMPLITUDE) | μSEC | 25 ± 2 |
| 9 | | BLANKING SIGNAL RISE TIME (MEASURED BETWEEN 10% & 90% AMPLITUDE) | μSEC | 3 MIN |
| 10 | | BLANKING SIGNAL FALL TIME (MEASURED BETWEEN 10% & 90% AMPLITUDE) | μSEC | 3 MIN |
| 11 | | SYNC PULSE RISE TIME (MEASURED BETWEEN 10% & 90% AMPLITUDE) | μSEC | 1.8 MIN |
| 12 | | SYNC PULSE FALL TIME (MEASURED BETWEEN 10% & 90% AMPLITUDE) | μSEC | 1.8 MIN |
| 13 | | BANDPASS OF VIDEO SOURCE AT INTERFACE | CPS | 1.5 TO $230 \times 10^3$ |
| 14 | | GROUP DELAY CONSTANT, FROM 600 cps TO 230 kcps WITHIN | μSEC | 1.0 |
| 15 | | BLACK REFERENCE LEVEL REFERRED TO VIDEO RETURN | VOLTS | -2.1 ± 0.1 |
| 16 | | | | |
| 17 | | | | |

Figure 2-18. Composite Video

### 2.2.7 Structure Electronics

The structure electronics performs the following functions:

a. Distributes power from the DC/DC converter to the PS components.

b. Contains the circuitry for the environmental control subsystem telemetry.

The 28-volt power from the spacecraft is delivered to the structure electronics, which routes it to the DC/DC converter. The converter supplies ±10 and ±6.5-volt outputs to the other PS components whenever the 28-volt power line is switched ON.

The ±20 and ±6.3-volt outputs from the converter are switched by the structure electronics via CAS-17 from the CCP. In addition, the structure electronics switches the ±20 and ±6.3-volt outputs from the V/H sensor (±20) and a load resistor (±6.3) to the read-out electronics via CAS-10. These outputs are returned to the V/H and load resistor by CAS-4.

The structure electronics provides the circuitry for the telemetry points listed in Table 2-6 See Figure 2-19 for a block diagram of the Structure Electronics.

TABLE 2-6

STRUCTURE ELECTRONICS TELEMETRY DESIGNATIONS

| TBC Designation | EKC Designation | Title |
|---|---|---|
| | HTL-6 | PS Power Line Voltage |
| | HTL-9 | PS Power Line Current |
| | TPL-4 | -20v Converter Output |
| | HTL-8 | +20v Converter Output |
| | TPL-3 | -6.5v Converter Output |
| | TPL-2 | +6.5v Converter Output |
| | TPL-5 | +6.3v Converter Output |
| | TPL-1 | -10v Converter Output |
| PE01 | VTL-23 | +10v Converter Output |
| | HTL-7 | +10v Converter Output |
| PH02 | ETL-35 | PS Humidity, Upper |
| PH01 | ETL-34 | PS Humidity, Lower |
| PT03 | CTL-4 | Window Temperature |
| PT09 | ETL-38 | Upper Shell Temperature |
| PT08 | ETL-37 | PS Environmental Temperature, Upper |
| PT07 | ETL-36 | PS Environmental Temperature, Lower |
| PT06 | RTL-32 | Readout & Thermal Fin Temperature |
| PT02 | ETL-39 | Pressure, N2 Bottle |

NOTES:
1. NON MIL-STD ABBREVIATIONS
PS = PHOTO SUBSYSTEM
V/H = VELOCITY HEIGHT

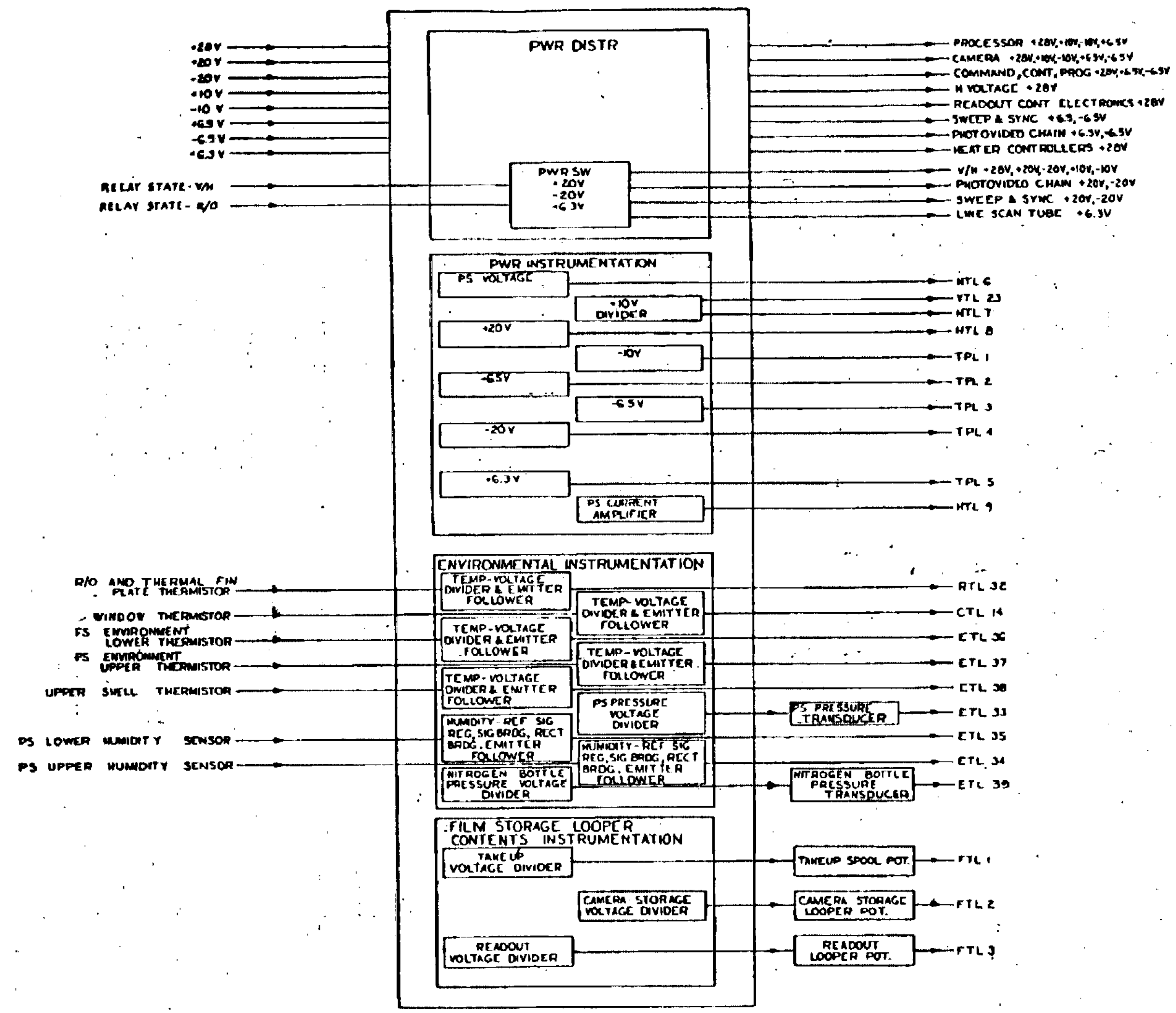



Figure 2-19. Structure Electronics Block Diagram

### 2.2.8 Film and Bimat

This section describes the photographic and physical properties of the film and Bimat used in the PS.

2.2.8.1 Photographic Film. The film used in the PS is Kodak Special High-Definition Aerial Film (Gray Base), Type SO-243. The film is photographic negative material which has extended red light (panchromatic) sensitivity. The film has low speed but extremely fine grain; when developed, an image of excellent resolving power results. The 0.0053-inch thick triacetate base is coated with an emulsion layer approximately 0.0005-inch thick, for a total thickness of 0.0058 inch. The relatively thick triacetate base provides a dimensionally stable support for the photographic image. The width of the film, in this application, is 70mm.

a. Spectral Sensitivity. Figure 2-20 is a plot of the relative spectral sensitivity of the film vs wavelength. The measurements were taken using SO-243 film processed in D-19 developer; however, the differences between the Bimat and D-19 process spectral sensitivity are small and can be neglected.

b. Characteristic Curve. The characteristic curve (or density vs Log exposure) for SO-243 processed by Bimat is shown in Figure 2-21. The Bimat method of processing, because it goes to completion, is relatively insensitive to changes in processing temperature and time. The characteristic curve shown represents a process-to-completion Bimat process.

c. Radiation Sensitivity. Radiation encountered during the Lunar Orbiter missions will come from three sources: Van Allen-belt radiation, galactic-cosmic radiation, and solar-flare radiation. It is expected that the amounts of radiation received from the Van Allen belts and from the galactic-cosmic sources will have little or no effect on the photographic mission. However, it is possible that solar-flare radiation could present a hazard to the mission goals.

Spectral Sensitivity of SO-243 Film with D-19 Processing to Density = 1.0

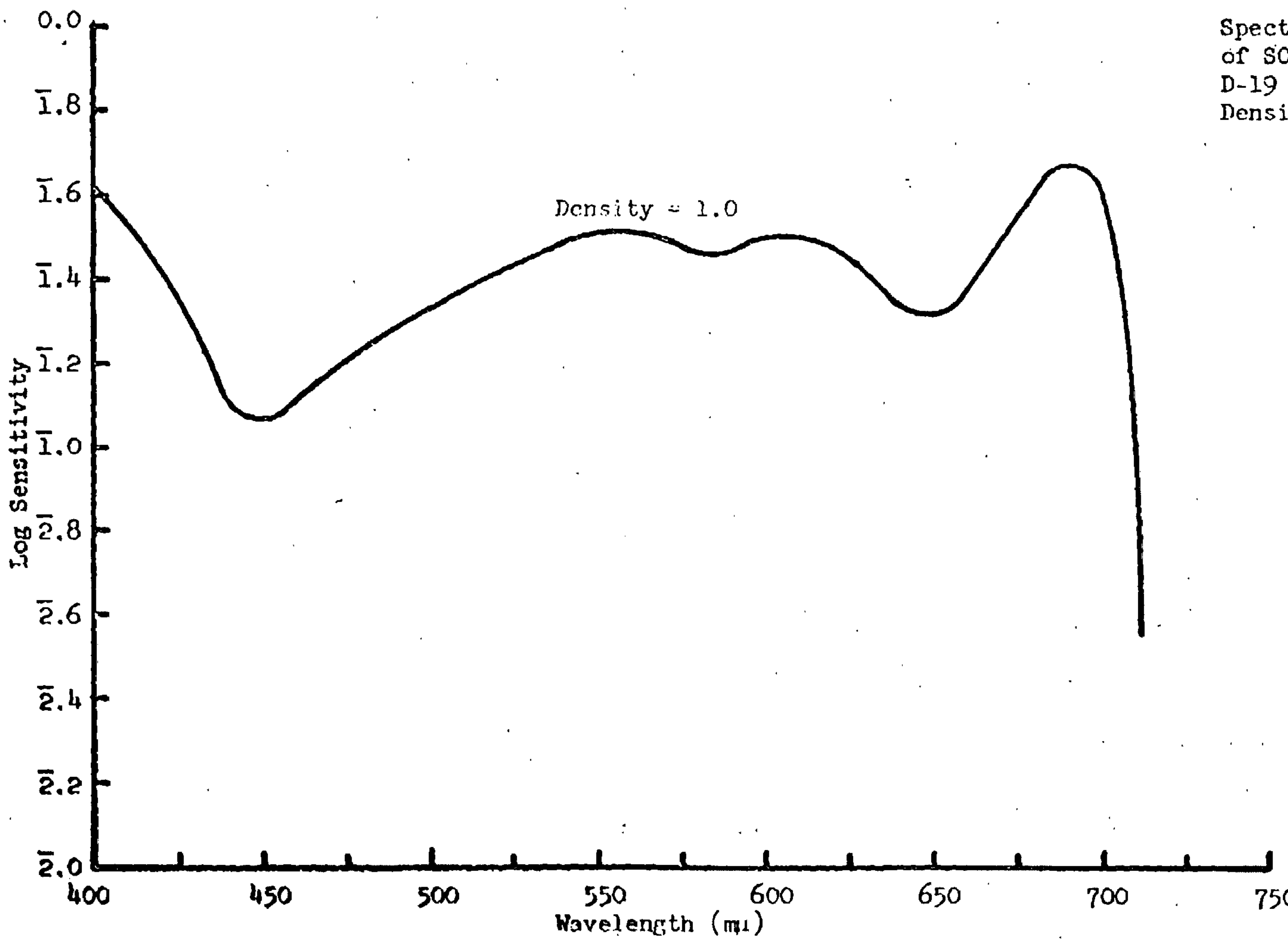



Figure 2-20. Spectral Sensitivity of SO-243 Film

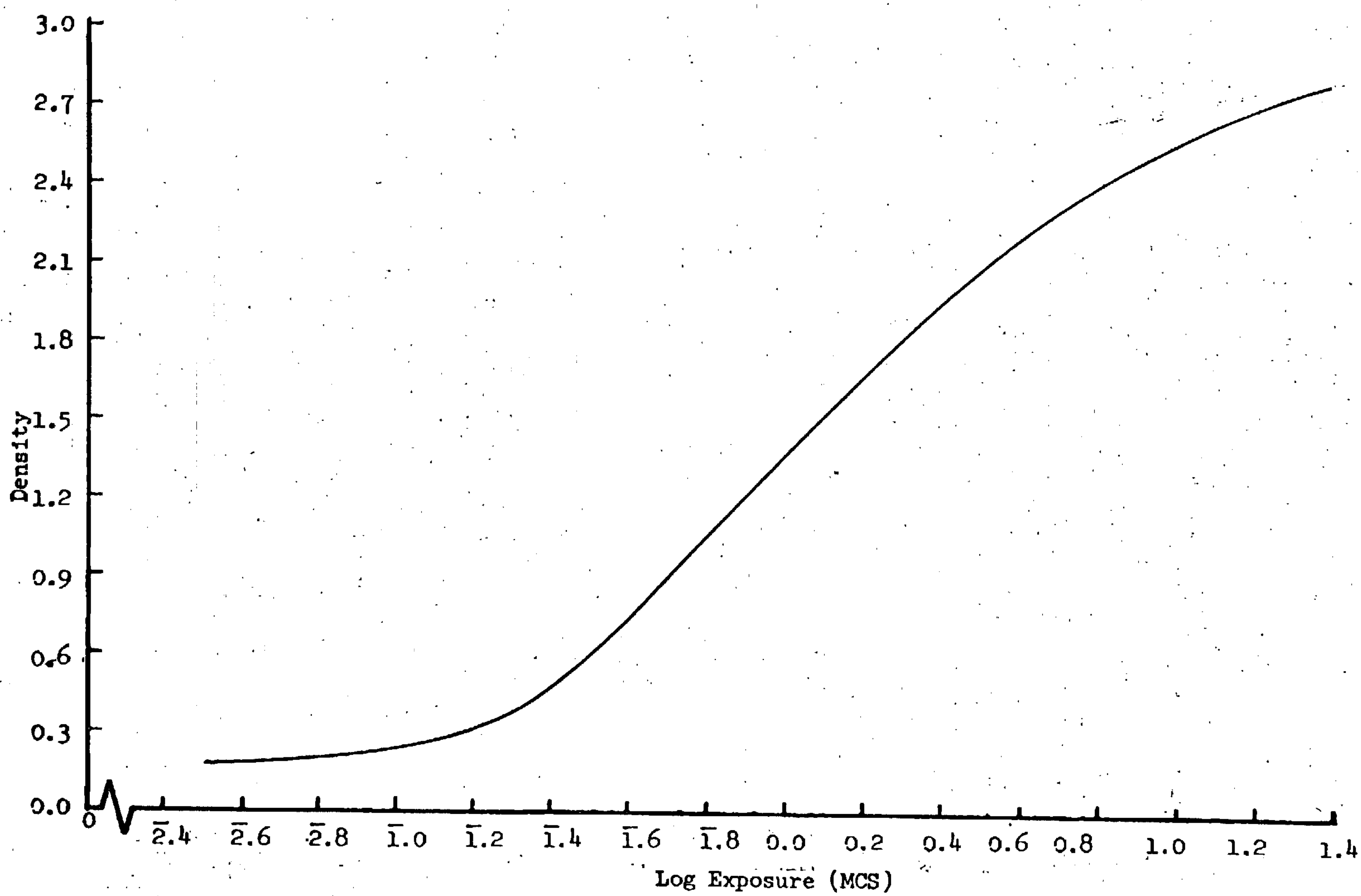



Figure 2-21. Characteristic Curve, Type SO-243 Film, Bimat Process. Measurements Taken with NH Blue Filter.

Radiation acts, as does non-image forming light, to produce high fog levels. The amount or density of the fog depends on the quantity of radiation energy absorbed by the film. Figure 2-22 shows the fog densities that can be expected for varying amounts of radiation. As shown in the figure, the amounts of absorbed radiation rather than the energy levels of the particles have the greatest effect on density variations.

Figure 2-23 shows the effect of radiation on the characteristic curve for SO-243 film. Radiation increases the fog density of the film and thus reduces its ability to form images of targets with low light intensities. Radiation also reduces the effective density range of the film because film densities greater than 1.3 are telemetered to the GRE as 1.3 density images. Radiation exposure of 10 rad units decreases the effective density range by approximately 10 percent. Radiation exposure of 100 rad units decreases the range by about 50 percent. Larger exposure amounts, of course, further decrease the film's effective density range.

Due to the inherent shielding of the spacecraft, the PS structure and the 2gm/cm$^2$ shielding provided by the film supply cassette, it is estimated that solar flares of magnitude 2 or less will have negligible effect on the undeveloped film. However, flares of magnitude 3 or greater can produce considerable fog on the film. Figure 2-24 is an estimate of the probability of a flare of magnitude 3 or greater occurring during the Lunar Orbiter missions. For any single mission the probability is about 16 percent.

From the figure it can be seen there is about a 57 percent probability that none of the missions will see a flare of magnitude 3 or greater and about a 99.8 percent probability that at least one of the five missions will not see such a flare. An average of about 10 solar flares occur each year and about 3 of these are of magnitude 3 or greater. However, there is no reliable method for predicting when these flares will occur.

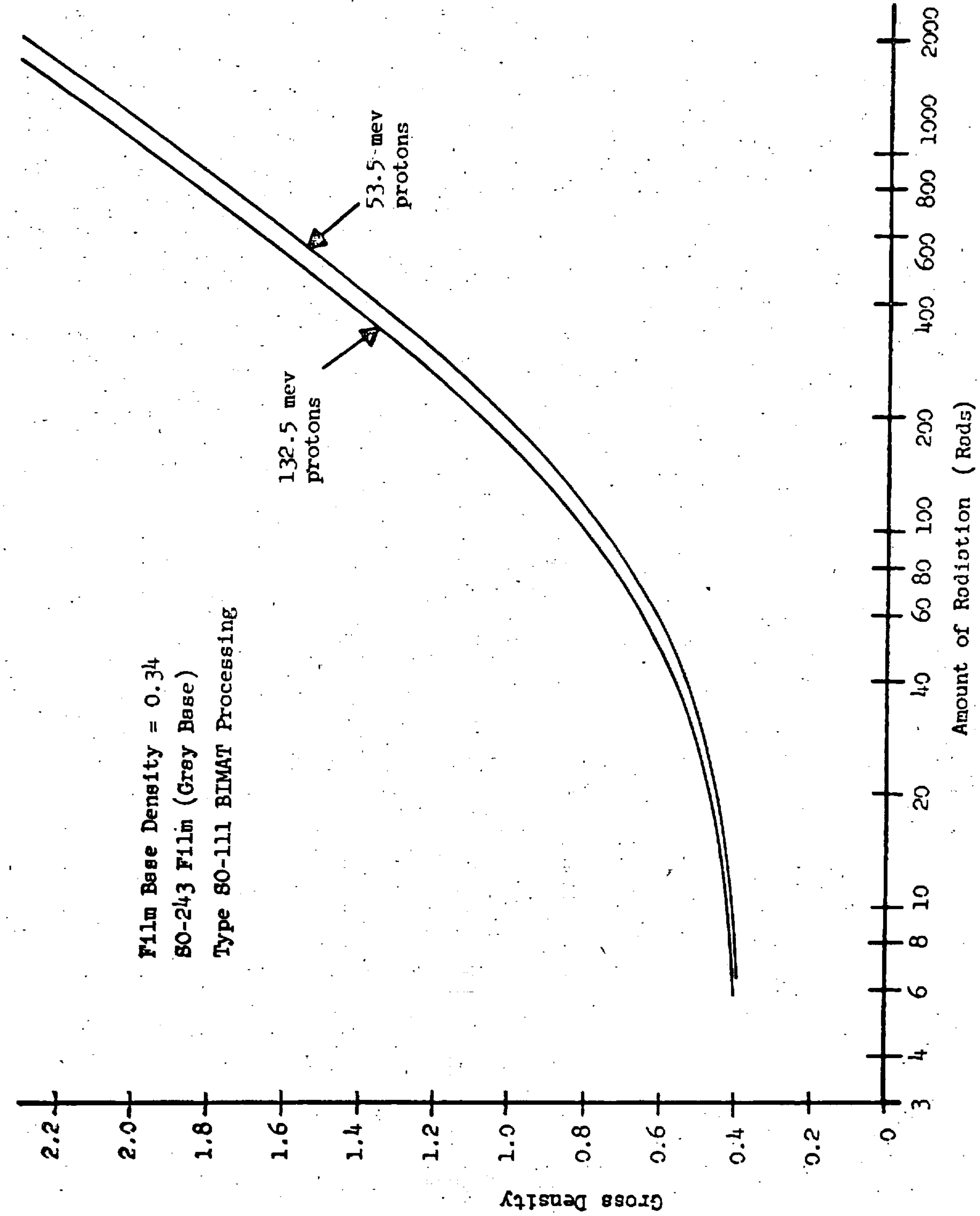



Figure 2-22. Gross Density vs Amount of Radiation

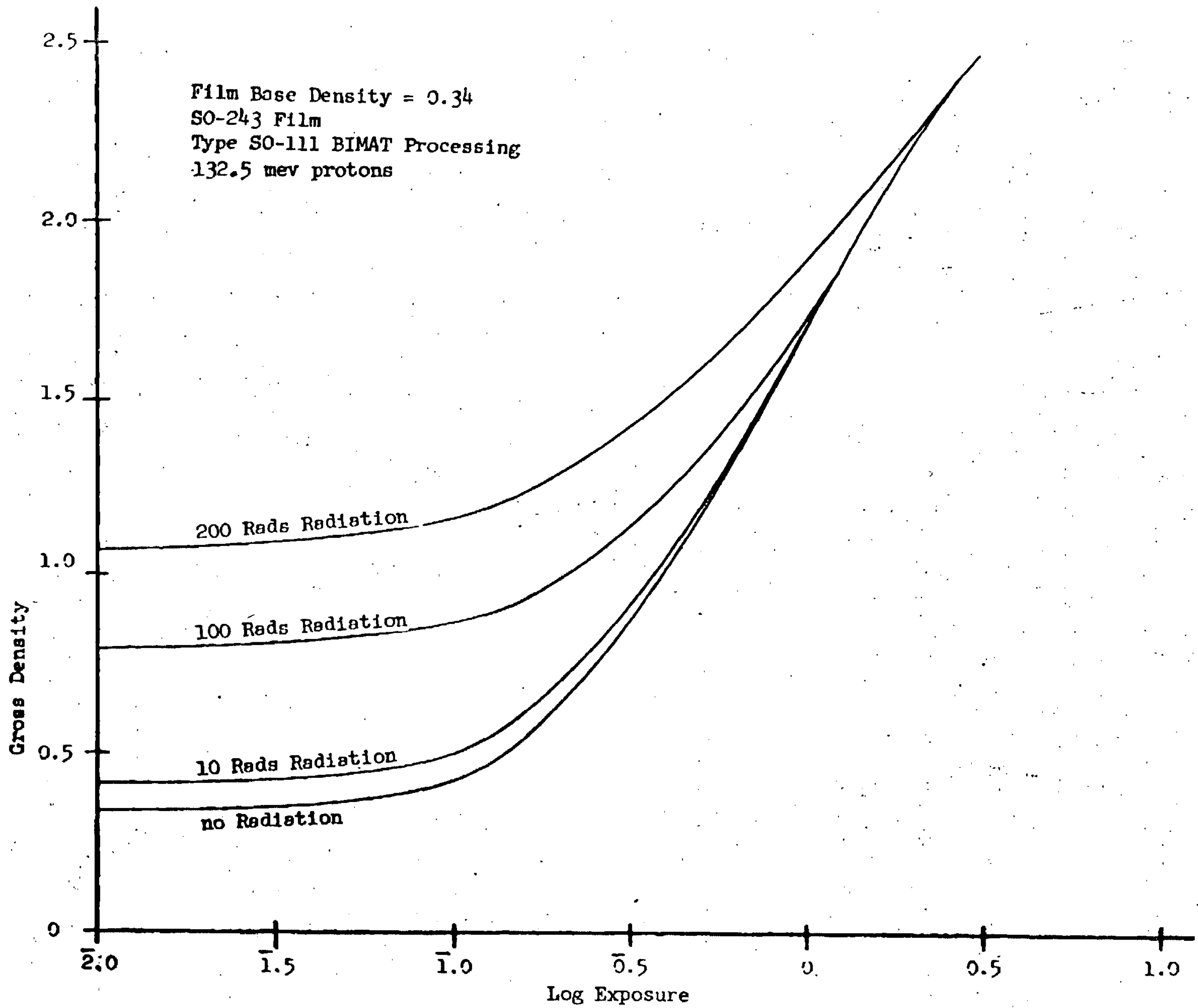



Figure 2-23. Gross Density vs Log Exposure (Characteristic Curve) for Various Amounts of Radiation

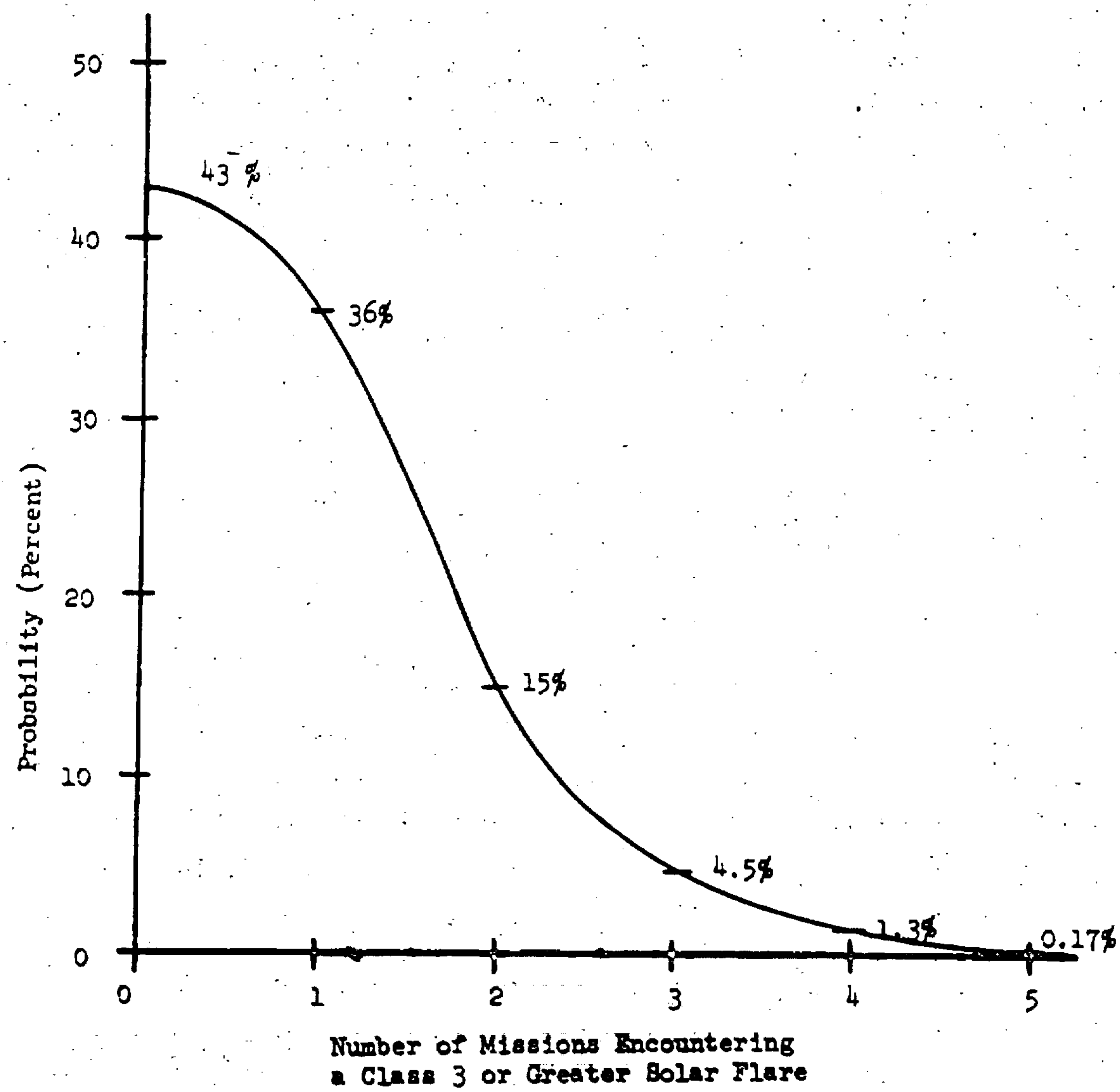



Figure 2-24. Probability of a 3 Magnitude or Greater Solar Flare Occurring During a Lunar Orbiter Mission

2.2.8.2 Bimat. The Bimat processing method used in the PS uses a special processing film, KODAK BIMAT Film (Estar Base), Type SO-111. The Bimat consists of a 0.004 polyester film support carrying a hydrophilic-gelatin layer which contains physical development nuclei. Before use, the Bimat is presoaked in Kodak Bimat Imbibant solution. The imbibant solution is a solvent-containing developer which develops and fixes the negative completely (and simultaneously) by the diffusion transfer method (see Figure 2-25). No further processing steps are required to use the developed images. The following sequence of events is descriptive of the Bimat process.

> When the exposed SO-243 is laminated against the Bimat, the Bimat solution begins to diffuse into the emulsion of the negative. Exposed negative grains of Silver Halide begin to develop and unexposed negative grains begin to dissolve in the silver halide solvent. Some of the dissolved silver halide diffuses into the Bimat film, where it is reduced to silver on the development nuclei present in the Bimat, and forms a positive image. The exposed silver halide grains are developed and retained in the SO-243, forming the usual negative image.

The Bimat processing method is self-limiting. When the two films are left in contact for a minimum time, the negative is both developed and fixed in a single step. When the films are left in contact for longer than the minimum time, the process merely goes to completion and no further reactions are possible. The sensitometric characteristics of both the SO-243 and the Bimat remain essentially unchanged for further contact time.

The Bimat process has the additional advantages of being relatively insensitive to temperature changes, or changes in processing times, provided that minimum requirements are met. However, it is necessary to control relative humidity in the processor/dryer to 50 ± 20 percent, to prevent the Bimat from drying out (this is accomplished through the use of salt pads - see paragraph 2.2.5, Processor/Dryer).

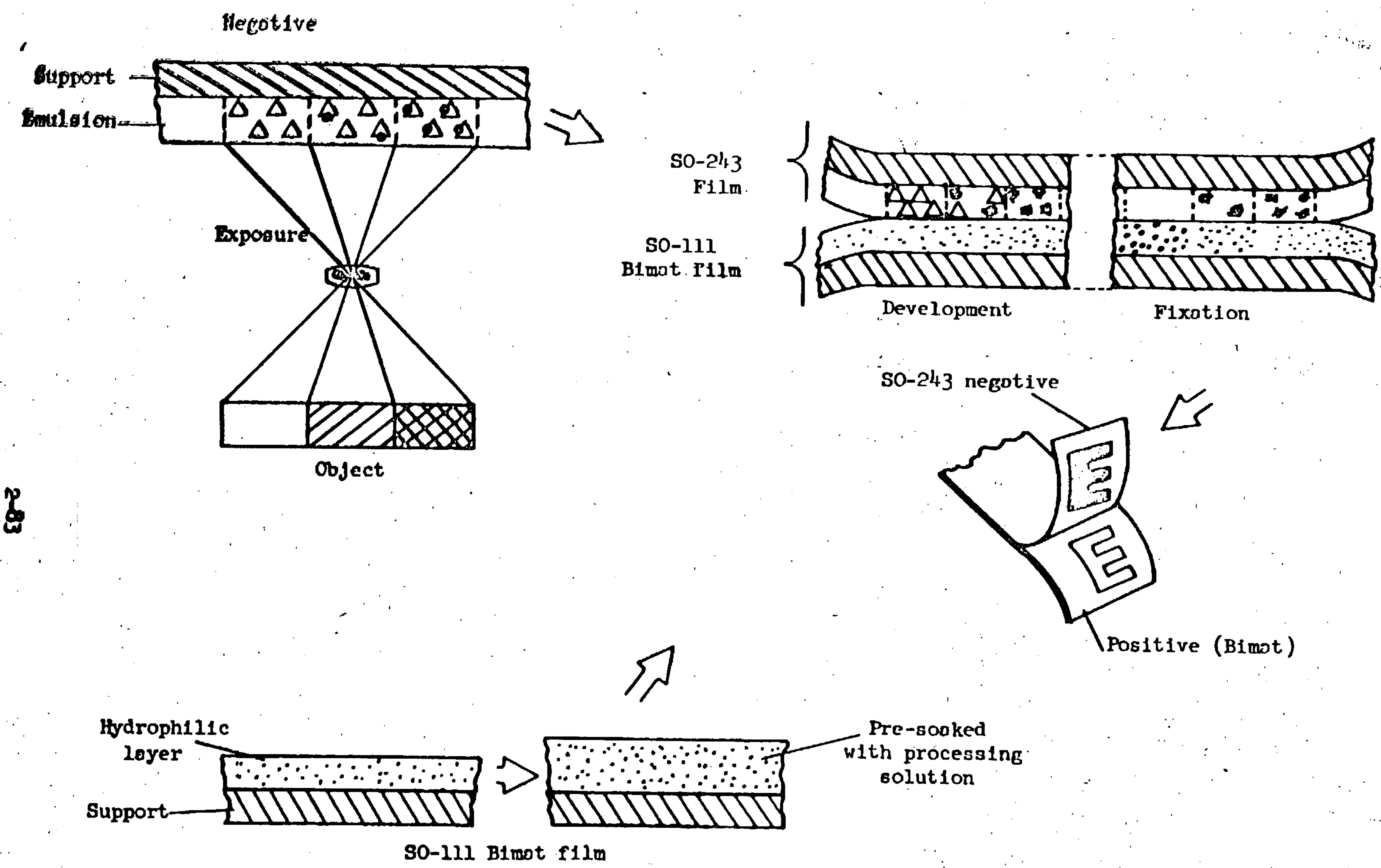



Figure 2-25. Bimat Processing Method

In addition, the film and Bimat if left in contact for greater than approximately 15 hours tend to laminate permanently and stick together. Because of this constraint, film must be programmed through the camera and processed at a minimum rate of 2 frames each 15 hours. Note that during the launch and translunar coast portion of the mission, active Bimat does not contact the film because a leader is attached to the Bimat. When mission photography begins, normal advance of film and Bimat through the system removes this leader from the processor/dryer.

### 2.2.9 Environmental Control

The environmental conditions which effect the operation of the PS are temperature, relative humidity, and pressure. These conditions are controlled throughout each mission to ensure satisfactory operation of the various components of the subsystem. The PS is designed to maintain internal component temperatures within allowable limits. During operation of these components, excess heat is dissipated through radiation and conduction to the spacecraft cold plate. When the components are not operating, resistance wire heaters are provided to compensate for PS heat losses.

Humidity control is provided through the use of potassium thiocynate crystals which absorb or release moisture to maintain relative humidity at 50 ± 20 percent.

Pressure control is accomplished by using a pressurized nitrogen bottle with a valve to maintain PS internal pressure between 1.0 and 1.9 psia.

Figure 2-26 is a sketch of the spacecraft showing the approximate location of the thermal control components.

2.2.9.1 Temperature. The heat sources for the thermal control system are resistance wire heaters located in strategic positions within the PS. The temperatures at these locations are sensed by thermistor probes which control the ON or OFF condition of the corresponding heater. In addition, all heaters can be turned OFF by the heater inhibit command (RTC-9), with the exception of the processor/dryer heaters. A list of these heaters and their locations is presented in Table 2-7.

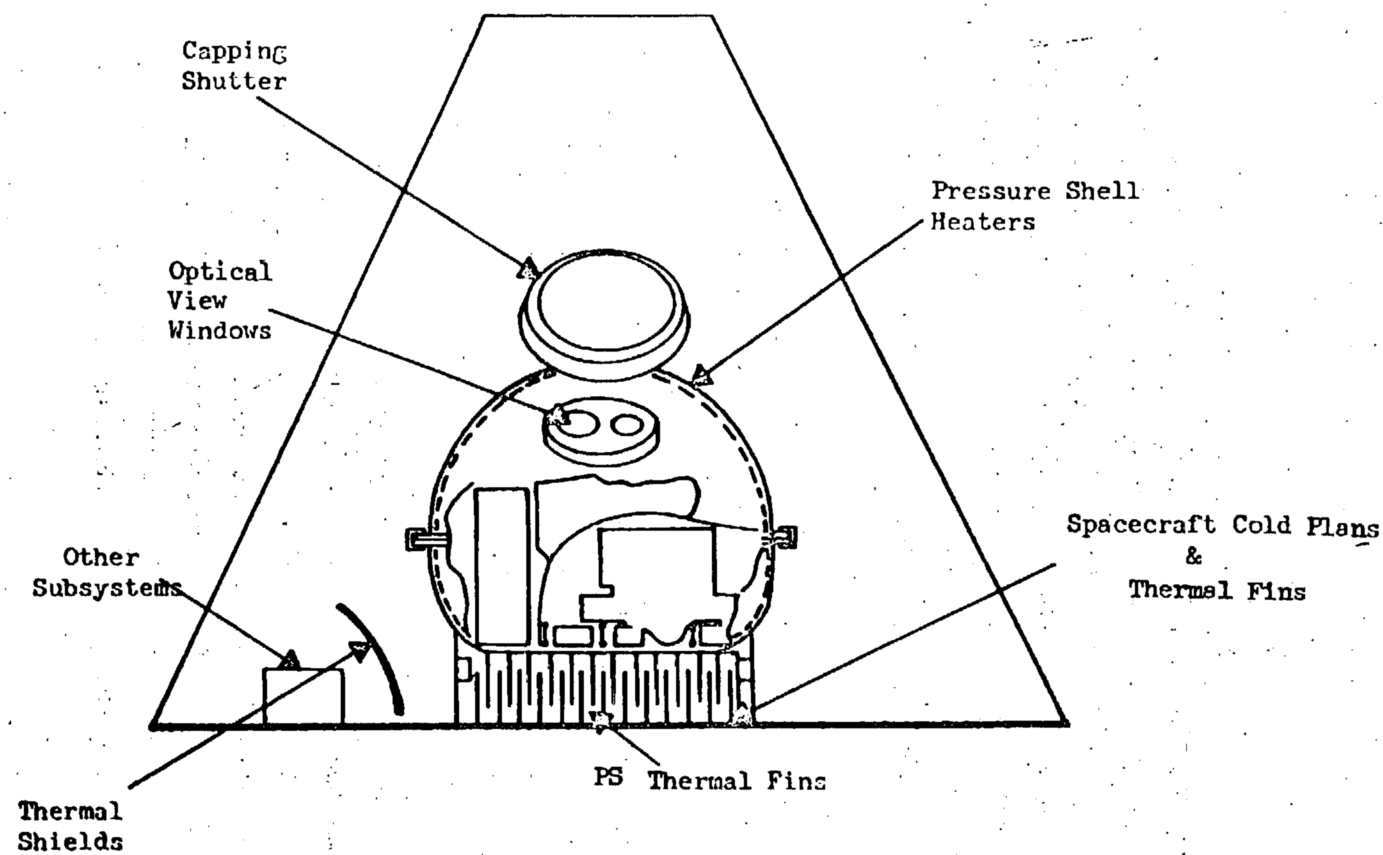



Figure 2-26. PS Thermal Control Features

TABLE 2-7

PS HEATERS

| Title | Location | Inhibited by CCP Signal | Resistance | Power Consumption (at 30.5 volts) |
|---|---|---|---|---|
| Pressure shell zone 1 | Entire upper pressure shell | CAS-19 | 120 Ω | 7.75 watts |
| Pressure shell zone 2 | Entire lower pressure shell except fin area | CAS-19 | 128 Ω | 7.28 watts |
| Pressure shell zone 3 | Thermal fin area 1 | CAS-19 | 53.5 Ω | 17.40 watts |
| | Thermal fin area 2 | CAS-18 | 198 Ω | 4.70 watts |
| | Thermal fin area 3 | CAS-19 | 52.5 Ω | 17.70 watts |
| Camera | Camera shroud | CAS-18 | 144 Ω | 6.46 watts |
| Window | Optical window | CAS-18 | 190 Ω | 4.90 watts |
| Lens | 24" lens | CAS-18 | 285 Ω | 3.26 watts |

Heat is also supplied by electrical power dissipation of the various subsystem components. Because the heat dissipations of these components are not controlled by temperature but are a function of the operating mode of the subsystem, an efficient method for cooling is provided. (The maximum power dissipations of the devices are given in paragraph 2.4.)

Excess heat in the PS is transmitted by conduction and radiation through thermal fins, located at the bottom of the lower pressure shell, to a mating set of fins attached to the spacecraft cold plate (equipment mounting deck - EMD). A low emissivity radiation shield (E = 0.06) thermally isolates the electrical and electronic packages from the temperature critical subassemblies such as the camera, processor, film, and Bimat. The less-temperature-critical and larger power-dissipating devices are located near the thermal fins and have emissivities of 0.92 so that a low thermal resistance path to the fins provides the necessary heat dissipation from the subsystem.

The emissivity of all non-power dissipating PS subassemblies such as the lens, camera enclosure, and pressure shell is 0.06. Large power dissipators and the thermal fins have an emissivity of 0.92. The thermal capacity of the PS subassemblies is 6.5 watt-hours per degree Fahrenheit. The thermal impedance of the optical window is 20F per watt or higher. The temperature of the thermal fin area is 35F minimum and 95F maximum; 170F is the highest mounting surface temperature of the electronic subassemblies, except for 180F allowed for the optical mechanical scanner motor. The optical window temperature is between 50 and 100F, and the gradient (center to periphery) is less than 10F. The 24-inch lens temperature is controlled to within ±1F of any nominal temperature between 65 and 75F. The Bimat temperature is limited to 75F maximum

prior to Bimat cut; after Bimat cut, no restrictions on Bimat temperature exist. The processor is controlled at 85F ± 2F and the dryer is controlled at 95 ± 5F.

2.2.9.2 Humidity. Humidity control is provided by potassium thiocynate crystals which absorb or release moisture when their capacity limits are exceeded. Stored in absorbent fiber pads at strategic locations within the pressure shell and processor, these crystals will keep the relative humidity within 30 to 70 percent as required by the photographic process. Drying of the film after the Bimat developing process will tend to increase the water vapor within the pressure shell; however, the water absorption quality of these crystals will compensate for this phenomenon. This characteristic will also prevent water condensation on possible cold spots within the shell.

2.2.9.3 Pressure. The environmental gas in the PS pressure shell is made up of 99 percent nitrogen and a total of 1 percent oxygen and other gases. Oxygen must be below 1 percent by volume to prevent loss of potency in the Bimat. Prior to launch, the nitrogen in the pressure shell is maintained at 1.9 psi above atmospheric pressure to prevent air leakage into the shell. This pressure differential is maintained throughout the launch phase by a relief valve which operates as the external pressure decreases.

During the photographic mission, pressure within the shell is maintained above 1.0 psia by nitrogen supplied from a pressurized bottle. This supply will allow for leakage equivalent to three pressure shell volumes of 1.0 psia at 70F. The lower pressure limit of 1.0 psia is required to keep the boiling point temperature of water above the expected temperatures of materials requiring moisture for operation such as the Bimat film and the humidity control pads.

2.2.10 Direct Current/Direct Current (DC/DC) Converter

The DC/DC converter provides the voltages used in the PS subassemblies from the 28v dc power supplied by the spacecraft. The voltages provided are: ±20, ±10, ±6.5, and ±6.3.

The DC/DC converter supplies ±10 and ±6.5v continuously, (that is, whenever the 28v dc spacecraft power is on), but switches the ±20 and ±6.3v outputs ON and OFF via a CCP command (CAS-17). A block diagram of the DC/DC converter is shown in Figure 2-27.

2.2.10.1 Continuous Outputs (±10 and ±6.5v dc). The input section of the converter consists of several filters to prevent transients and pulse-width-regulator spikes from being placed on the input line. The input power, which is now filtered, is used to run a low-power oscillator, whose ac output is stepped down by a transformer. The output from one pair of secondary windings is rectified and filtered and then passed through conventional series regulators, producing the ±10v outputs. The other pair of secondary windings has the same components, plus a current sensing element which controls the regulators. This produces the ±6.5v dc outputs. If an overload current is sensed, the ±6.5v outputs drop to zero volts for about 1 to 1 1/2 seconds, after which time the voltage is brought back up. If the overload is still present, the outputs are shut down again, etc.

2.2.10.2 Switched Outputs (±20 and +6.3v dc). The filtered 28v dc is also routed to a pulse-width regulator. The regulator functions by chopping and then integrating the d-c input. In this manner, the duty cycle of the chopping alters the d-c output voltage. The output voltage then runs a high-power oscillator. The oscillator output is coupled through a transformer to rectifiers, filters, and series regulators to produce the ±20 and +6.3v dc outputs. The sensing for controlling the pulse-width regulator

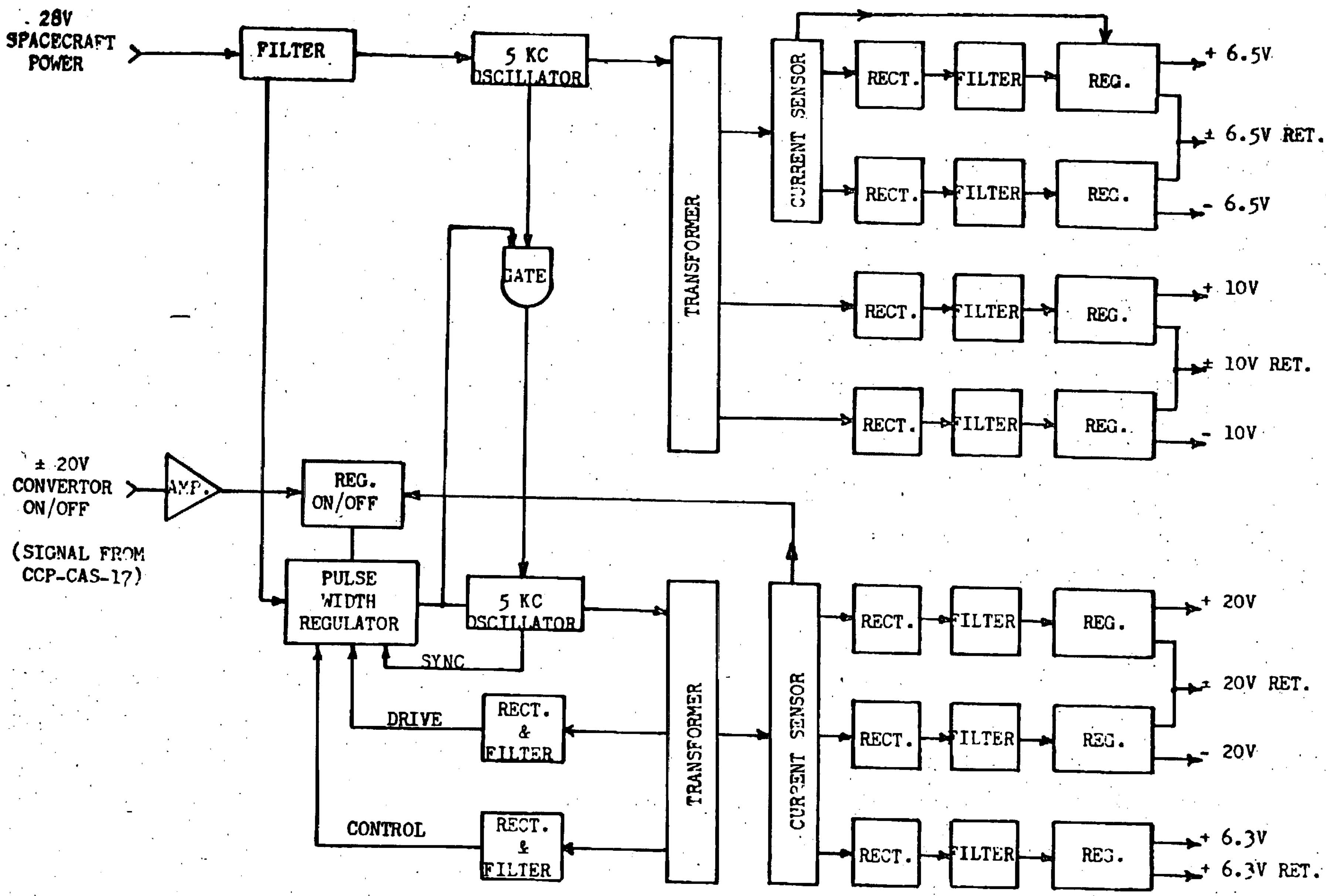



Figure 2-27. DC/DC Converter Block Diagram

is provided by a separate winding of the transformer which, after being rectified and filtered, compensates for variations through the oscillator and transformer. Another winding steps up the 28v dc to provide an operating voltage for the pulse-width regulator (drive line). The two oscillators and the chopper in the pulse-width regulator are all synchronized to prevent low-frequency current beats on the input line.

The pulse width regulator can be shut off by either the absence of CAS-17 or an overload current on any one of the +20, -20, or +6.3v dc lines. When shut down by an overload, the regulator will cycle as described in paragraph 2.2.10.1. When the pulse width regulator is off, the sync pulse from the low power oscillator is gated OFF to prevent oscillator loading.

## 2.3 SEQUENCE AND MODES OF OPERATION, AND PROGRAMMING CONSTRAINTS

The PS modes of operation are determined and controlled by the CCP, which in turn receives commands to operate in a given mode from the Boeing command subsystem. To understand the PS operations in each CCP mode, it is important to be familiar with the normal sequence of events as they occur when the PS photographs the moon. Therefore, a discussion of the sequence of events which occur during photography is included with this section.

### 2.3.1 Sequence of Events

2.3.1.1 Photography with V/H Sensor OFF. The normal sequence of events during photography for the case when the V/H sensor is OFF is as follows:

a. The camera program memory (in the CCP) receives three commands, which specify the spacing between exposures and the number of exposures to be taken. These commands consist of one command from each of the following groups:

| | | |
|---|---|---|
| (1) | SPC 26/27 | fast/slow camera rate |
| (2) | SPC 28/29 | frame count A/not A |
| (3) | SPC 30/31 | frame count B/not B |

Note: The two frame-count commands are input in the form of a binary one or zero for a total of 4 possible combinations. In this manner, the frame count is selected to be 1, 4, 8, or 16 frames by these two commands. See paragraph 2.3.2.1.

b. Command SPC 2 turns the camera electronics ON. This command also starts the auxiliary 0.4-cps generator (used in place of the V/H output), initiating the photographic cycle.

c. A single-shot pulse from the 0.4 cps generator of 0.625-second duration activates the mechanical film clamp and vacuum draw until the pulse ends.

Note: No platen IMC motion takes place, because the platen is driven directly by the V/H output cam and the V/H sensor is OFF.

d. Then, 0.253 second after the initiation of the 0.625 second pulse, another pulse (also from the 0.4 cps generator) activates (1) the 3-inch shutter motor (0.200 seconds duration), (2) the 24-inch shutter clutch, and (3) the date lamps (0.050 seconds).

e. At the end of the 24-inch shutter traverse, the shutter limit switch actuates sending a disengage signal to the shutter clutch, allowing the shutter return motor to reset the shutter.

f. The end of the 0.625 second pulse is sensed by the film-advance electronics which turns ON the film-advance motor. Metering of 11.7 inches of film through the camera is accomplished in less than 1 second.

g. When the film advances, the supply spool and supply looper are active, delivering 11.7 inches of film to the camera. When the supply looper is not FULL, an electro-magnetic brake on the supply spool is released and the supply looper tension spring pulls film from the spool until the supply looper is FULL, at which time the brake is reapplied. The ON-OFF of the brake is controlled by the full switch on the supply looper.

h. As the film advances, the camera storage looper accepts the advanced film.

i. After a preset number of exposures (1, 4, 8, or 16) the camera program memory signals the camera electronics to shut OFF, which ends the photo sequence.

j. The processor motor, processor heater, and dryer heater start immediately upon receiving the camera OFF signal if the following conditions are met:

(1) Read-out electronics OFF
(2) Bimat not clear
(3) Camera storage looper not EMPTY
(4) No solar eclipse (solar eclipse memory OFF)
(5) V/H OFF
(6) Read-out release memory ON (set)

A tension differential produced by the looper springs and the action of the Bimat drive motor causes the processed film to proceed from the processor/dryer, into the read-out looper. When the read-out looper is partially FULL (about 3 inches of film), the read-out looper partial full switch activates the take-up drive motor which empties the read-out looper. When the read-out looper is EMPTY, the read-out-looper empty switch turns the take-up drive motor OFF. This process continues until film is no longer provided to the read-out looper by the processor/dryer. During this procedure, the take-up looper is a passive device and has no control over the take-up sequence.

k. When the camera storage looper has been emptied, the looper provides a signal to the CCP, which turns the processor/dryer OFF.

2.3.1.2 Photography with V/H Sensor ON. The photographic sequence of events with the V/H sensor ON is only slightly different than the sequence when the V/H sensor is OFF. The major change which occurs has to do with the camera framing rate (that is, time between consecutive exposures) and, of course, IMC will now be provided by platen movement during photography. When the V/H is OFF, the frame spacing is determined by the 0.4-cps generator, and is either 2.3 or 9.2 seconds. However, when the V/H sensor is ON, the frame spacing is determined by the V/H rate. Thus, camera framing rate, like IMC velocity, is a function of the orbit. This feature is provided to ensure that high resolution frames have a minimum of 5 percent overlap when operating in the fast-camera mode. The framing rate is thus a variable between the following limits, as a function of V/H:

| Slow Camera Rate (Seconds/frame) | Fast Camera Rate (Seconds/frame) | IMC Velocity (mm/second) | V/H Ratio (Seconds $^{-1}$) |
|---|---|---|---|
| 41.20 | 10.30 | 4.88 | 0.008 |
| 6.58 | 1.65 | 30.50 | 0.050 |

The normal sequence of events during photography with V/H ON is given below:

a. Command SPC-1 turns the V/H sensor ON. The V/H output shaft provides IMC and camera-frame spacing. Both platens cycle continuously whenever the V/H sensor is on.

b. After approximately 2 minutes of V/H operation (required for stabilization), the CCP receives one each of commands SPC 26/27, SPC 28/29, and SPC 30/31, which select the framing rate and the number of frames to be taken.

c. Command SPC-2 turns the camera electronics ON. The photographic sequence begins when the V/H output shaft reaches the 0 degree reference position. A maximum of 2.1 seconds is required for this event to occur.

d. At the 0 degree output-shaft position, the intervalometer signals the CCP which initiates film clamp and vacuum draw. The V/H output cam starts the platens moving backward, preparing for the exposure.

e. The V/H output cam then moves the platens forward at the correct velocity, to produce IMC. (The 24-inch platen is driven by the output shaft; the 80-mm platen is coupled to the 24-inch platen with a lever arm, and thus is driven by this component at a different velocity, rather than directly by the output shaft).

f. While the platen forward movement is under way, the following events are initiated by the CCP in response to signals from the V/H intervalometer:

   (1) The 80-mm shutter motor is actuated (0.200 seconds)
   (2) The time-code data lamps operate (0.050 seconds)
   (3) The 24-inch shutter begins operation

   At the end of the 24-inch shutter traverse, the shutter limit switch sends a signal to the shutter return motor, via the CCP, which returns the curtains to the pre-exposure position.

g. The output shaft then returns the platen to the center position and a signal from the intervalometer ends the film clamp and draw vacuum sequence. This intervalometer signal also turns ON the film advance motor. 11.7 inches of film is drawn through the camera in less than 1 second. Film is drawn out of the supply looper and reel as described previously.

h. The advanced film is stored in the camera storage looper.

i. After film advance, a time interval occurs before the next photograph, depending on the velocity of the V/H output shaft and the fast/slow framing rate which has been selected.

Note: Film clamp and vacuum draw take place for each rotation of the V/H output shaft even though exposure and film advance may take place only every fourth revolution of the output shaft (slow camera rate).

j. Additional frames are then executed, according to the number of frames which have been commanded by SPC's 28 or 29, and 30 or 31.

k. When the correct number of frames have been executed, the camera memory is turned OFF, ending the photographic sequence. If more than one frame has been programmed, the V/H sensor is turned OFF by the same signal which turns OFF the camera memory. If a single frame sequence has been programmed, an SPC-4 command will normally be given to turn the V/H sensor OFF.

l. Upon receiving the camera OFF signal, the processor motor, dryer heater, and processor heater start immediately, if the following conditions are met:

(1) Read-out electronics OFF
(2) Bimat not clear
(3) Camera storage looper not empty
(4) No solar eclipse
(5) V/H sensor OFF
(6) Read-out release memory ON (Set)

m. The processor runs continuously at the rate of 2.4 inches/minute until all film in the camera storage looper has been processed. The film from the processor/dryer (P/D) passes into the empty read-out looper by means of the Bimat drive motor and the tension springs in the read-out looper. When the read-out looper has partially filled, the looper partial-full switch activates the take-up drive motor which draws film from the looper. When the looper has been emptied, the read-out looper empty switch shuts OFF the motor. The looper refills as film is supplied from the processor. This process continues until the P/D no longer provides film to the take-up looper.

n. When the camera storage looper has been emptied, the P/D is shut OFF by the looper empty switch.

2.3.1.3 <u>Quick-Look Read-Out.</u> The steps given above take place for all photographic sequences which use the V/H sensor. At times during the mission, it may be desirable to read out a portion of the photographs before all photography is complete. This read-out can be accomplished by operating the PS in the quick-look read-out mode. The sequence of events for this mode is as follows:

a. Command SPC-3 is given, turning the read-out electronics memory ON.

b. The output of the R/O memory starts the line-scan-tube (LST) drum motor, switches ±20 and 6.3 volts to the read-out electronics, and reverses the operation of the take-up motor. The take-up motor drives film into the take-up looper (which fills via tension springs) until turned OFF by the looper-full switch.

c. After a 10 millisecond delay, (1) the line scan tube filament turns ON, and (2) the sync generator: initiates the spot sweep, supplies the sync signal to the video amplifier and sends the key-clamp signal to the video transmitter.

d. After a nominal 20-second delay, the high voltage is turned ON.

e. Command RTC-5 (R/O drive ON) is then given. This command causes the scanner to move to the focus-spot stop area and clamps the film. Because the scanner is parked on the pre-exposed film edge where focus lines and a reference 0.3 density are present, the following adjustments can be made at this time by real time commands.

   (1) Photo video gain adjust - increase or decrease (RTC-13-14).
   (2) LST focus adjust - increase or decrease (RTC-11-12).

f. R/O drive ON (RTC-5) is again given. The scan motor starts and drives the lens carriage across the film width.

g. At carriage turn-around the film gate is opened by camming pressure and the film is advanced 0.100 ± 0.0002 inch through the R/O gate.

h. The lens carriage moves across the film width again, scanning the next framelet as it does so. Thus, adjacent framelets are read out with the optical mechanical scanner operating in opposite directions.

i. On every second turn-around the scan spot passes the pre-exposed density strip. Careful monitoring of the video signal at the DSS will indicate whether scanning should be stopped to make adjustments to LST focus and/or photo video gain.

j. Scan is continued until R/O is commanded OFF. R/O OFF can be accomplished by one of the following commands, or logic functions (however, the normal procedure is to use the R/O drive OFF command, RTC-6):

   (1) R/O looper full (RLF) switch is actuated (this looper has a capacity of approximately 4 frames)
   (2) Solar eclipse ON (SPC-18) is received
   (3) Read-out drive OFF (RTC-6) is received
   (4) Camera ON (SPC-2) is received

k. In case j (1) the scanner continues until the spot-stop (SPS) switch closes, the film clamp opens. (Note: The R/O drive operation can continue for up to two scans across the film, or approximately 46 seconds after it is commanded OFF). The following then occurs:

(1) R/O electronics, drive motor, drum motor, and voltage converters are turned OFF.
(2) The forward release turns ON and disengages the R/O drive clutch, if processing is enabled by film in the camera storage looper.* The take-up drive is switched to the forward mode.
(3) Because the read-out looper is more than partially full (entirely full if case j(1) has occurred), the take-up drive remains ON until the read-out looper is EMPTY. When the read-out looper empty switch is opened, the take-up drive is deactivated, the forward release is turned OFF, and the R/O drive clutch is re-engaged.

l. For case j(2), j(3), or j(4), the scanner continues until the spot-stop switch (SPS) is closed and the OMS film clamp is opened. The following then occurs:

(1) R/O electronics, drive motor, drum motor, and voltage converters are turned OFF.
(2) The forward release remains OFF and the R/O ends leaving the R/O looper partially full.

m. After the R/O has been commanded OFF (see step j), one of the following can be received:

(1) R/O electronics ON (SPC-3)
(2) Wind forward (RTC-16)
(3) Camera ON (SPC-2)

n. For case m(1) steps b through l are repeated.

o. For case m(2), the following occurs:

---

* If processing is not enabled, no further action takes place until processing is enabled by putting film into the camera storage looper.

(1) Forward release turns ON, and processing is enabled if film is available in the camera storage looper.
(2) The take-up drive is switched to the forward mode. The read-out looper partial full switch activates the take-up drive. The take-up drive remains ON until the read-out looper is EMPTY. The EMPTY switch is opened and the take-up drive is deactivated.

p. For case m(3), the camera is turned ON, and a photographic sequence occurs.

2.3.1.4 Final Read-Out. After the completion of photography, final read-out of the exposed and processed film takes place. To accomplish this, the Bimat is cut and cleared from the film transport system by winding a portion of the loose end on the Bimat take-up spool. When this is complete, the film is run backwards into the R/O and camera storage loopers while read-out takes place in 0.100-inch increments. (Film is then wound on the supply reel each time the R/O is turned OFF.) The sequence of events is as follows:

a. Ten minutes before the completion of processing of the last photo frames, command RTC-8 is sent to cut the Bimat web. Upon receipt of RTC-8, the Bimat cut electronics in the CCP sends signal CAS-6 which switches current to a nichrome wire in a groove on the Bimat roller. The wire heats, expands out of the groove, and pushes against the Bimat. The hot wire cuts through the Bimat in a maximum of 8 seconds. An encoder senses when the loose end of the cut Bimat has cleared the Bimat cut rollers and inhibits further power to the Bimat cut wire. After the Bimat has been cut, the portion between the cut and the take-up spool continues to wind on the Bimat take-up. The Bimat-drive operates until a sensor detects the Bimat clear condition and the resulting signal (BMC) stops the Bimat drive.* The film

* A small spring-loaded roller on a follower arm falls into a matching groove on another roller which is uncovered when BMC occurs. The follower arm then rotates and an encoder attached to the pivot point sends BMC to the CCP.

handling system reverses to move film backwards through the PS for final read-out, using the reversed camera advance and take-up motors, and the supply-spool drive motor. Reversal of the polarity to the camera advance and take-up motors is accomplished by relays in the camera electronics and read-out control electronics by the BMC signal and the CCP logic circuitry.

b. The other events which occur during final read-out are the same as described previously for the quick-look read-out mode, except:

(1) Bimat is no longer contacting the film.
(2) Film moves backwards through the entire system as the read-out looper fills and is emptied by the action of the camera storage looper and the film-supply spool (now acting as a take-up spool).

### 2.3.2 Modes of Operation

There are 11 normal PS operating modes, each of which are controlled by the CCP as it responds to commands from the spacecraft command subsystem. These modes are discussed in the following paragraphs. The normal mode-to-mode transitions which can occur are given in paragraph 2.3.3.

2.3.2.1 Photographic Mode. The mode of PS operation when the camera is operating is referred to as the photographic mode; however, the photographic mode, with respect to the CCP is defined as the mode of operation when the camera memory is ON.

The possible photographic sequences can be classified according to repetition rate, and to the number of frames per sequence.

a. Repetition Rate - The repetition rate of a photographic sequence will be a function of the V/H rate when a sequence occurs while the V/H sensor is ON, and will be fixed at a nominal rate when a sequence occurs while the V/H sensor is OFF.

The draw vacuum and clamp film (DV and CF) switch, and the shutter and sync switch (both from the intervalometer shaft encoder) are the inputs to the CCP that are used to control the repetition rate of the camera when the V/H sensor is ON. If the camera is enabled when the V/H sensor is OFF, a multivibrator within the CCP drives an electrical intervalometer and generates signals necessary to operate the camera at either of two fixed repetition rates. The photographic repetition rate, as a function of the V/H rate, can be altered by a factor of four. The shift is accomplished within the CCP by setting a two-stage counter to count down either by one (fast camera rate) or to count down by four (slow camera rate). The signal that sets the counter is provided from the frame-rate memory, which is set with SPC-26 (fast camera rate) and cleared with SPC-27 (slow camera rate). There is no constraint on the application of these two commands except that an SPC-26 command given during a photographic sequence will be ignored. The nominal frame rate generated when the V/H sensor is OFF can also be altered by a factor of four in the same manner.

b. Frames per Sequence - The number of frames in a sequence is preselected by two of four commands: SPC-28 or SPC-29, and SPC-30 or SPC-31. These commands set a frame-count memory. The output of the frame-count memory gates the output of a frame counter to provide a clear signal to the camera memory when the correct number of frames have been taken, terminating the sequence. The frame count can be preset by command to 1, 4, 8, or 16 frames as shown in the following table:

| Mode | | Commands* | | | | | | Instrumentation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Repetition Rate | Number of Frames | SPC 26 | SPC 27 | SPC 28 | SPC 29 | SPC 30 | SPC 31 | CTL 10a | CTL 10b | CTL 10c |
| Fast | 16 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| Fast | 8 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| Fast | 4 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| Slow | 16 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| Slow | 8 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| Slow | 4 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| Single frame | 1 | - | - | 1 | 0 | 1 | 0 | - | 0 | 0 |

A sequence of any number of frames is possible if the camera storage looper is sufficiently empty to accept these frames. If the frame-count commands are given during a camera operation sequence, an indeterminate number of frames, limited by the capacity of the camera storage looper, can result. If the frame-count setting is larger than the capacity of the camera storage looper, the number of frames will be limited by the capacity of the looper, and the sequences will terminate via the looper-full-switch signal. The photographic sequence will end when completed, or when an inhibition signal or SPC-4 (V/H OFF

* **Only one each of commands SPC 26 and 27, 28 and 29, and 30 and 31 are given. In this table, a binary one means the command is given; a zero means that it is not given.**

command) occurs; if terminated by an inhibition signal, a sequence of fewer frames than was selected can result. The photographic sequence will be inhibited: (1) during solar eclipse, (2) when camera storage looper is less than 1 frame from full, or (3) when the read-out mode is enabled by an SPC-3 command (read-out electronics ON).

c. Camera Control - The photographic sequence selected with SPC-26 or 27, SPC-28 or 29, and 30 or 31 will be initiated when SPC-2 (camera ON command) is given. SPC-2 sets the camera memory. The output of the camera memory enables the camera-control signal logic, which provides switching signals to the camera. When the V/H sensor is used, SPC-1 (V/H ON) should precede SPC-2 (camera ON) for the interval required for V/H sensor stabilization. The V/H sensor will be turned OFF automatically at the end of a sequence, with the exception of the single-frame sequence. When the single-frame sequence is used, the V/H sensor must be turned OFF by SPC-4 (V/H OFF command). All PS heaters are inhibited when the camera memory is ON. The control signals from the CCP to the camera include:

(1) The 24-inch shutter motor signals (MS-1, MS-2) are present when the camera memory is ON.
(2) The film clamp (CAS-2) signal is coincident with the DV and CF switch input. When the V/H sensor is not used, CAS-2 is generated from a multivibrator within the CCP.
(3) The 24-inch shutter clutch (CAS-8) signal is a 50 ± 10 millisecond pulse keyed to the shutter and sync switch input when the V/H is ON, and from the multivibrator within the CCP when the V/H is OFF.
(4) The 80-mm shutter (CAS-3)signal is keyed ON from the shutter and sync switch input when V/H is ON or the multivibrator within the CCP when the V/H is OFF, and is keyed OFF from the 80-mm shutter limit switch input (SHL).

(5) The camera film drive forward (CAS-1) signal is keyed ON from the film clamp signal (CAS-2), and OFF from the end-of-film-advance switch input (EOS). Although signal CAS-2 always repeats at a fast rate if the V/H sensor is operating, signal CAS-1 occurs at either a fast or slow rate depending on the state of the FAST/SLOW memory.

(6) The camera film drive ON/OFF (CAS-5) signal is keyed from CAS-1 (camera film drive forward) so the leading edge of CAS-5 lags the leading edge of CAS-1 by nominally 40 milliseconds; their trailing edges are coincident.

(7) The time code interrogation (TCI) pulse is a 50 ± 10 millisecond pulse which occurs when the shutters are activated.

A CAS-8 and CAS-3 signal (24-inch and 80-mm shutters) will occur for each shutter and sync switch input signal when the camera memory is ON, and has been ON before (or within 50 milliseconds after) the corresponding DV and CF switch signal, if the camera program is set for the fast camera rate. When the camera program is set for the slow camera rate a CAS-8 and a CAS-3 signal will occur for the first shutter and sync switch signal that occurs after the camera memory is ON, if the camera came ON before (or within 50 milliseconds after) the corresponding DV and CF switch signal, and for every fourth shutter and sync switch signal that occurs thereafter. A CAS-1 signal (camera film drive forward) is keyed ON from the trailing edge of the CAS-2 signals which correspond to the shutter signals CAS-3 and CAS-8. The shutter and sync switch input signal and the DV and CF signal are simulated by the internal multivibrator if the V/H sensor is not turned ON.

Control signals (2) through (7) recur for each frame of photography. Because the leading edge of the DV and CF switch input must occur when the camera is ON to start the cycle of control signals for a frame, and because the intervalometer shaft encoder will return to a stop position when the V/H sensor is turned OFF, all the control signals for one frame

of photography will occur in a normal cycle (that is, one rotation of the V/H output cam and intervalometer) with the exception of sequence termination by solar eclipse. When solar eclipse ON command is given during a frame of photography, the exposure of the frame will be completed but the film will not be advanced until the solar eclipse OFF command is given.

d. Film Transport - During the photographic mode, the supply brake is released when the supply looper is not full. Thus, when film is pulled from the supply looper by the camera film advance, the supply brake will be released and the looper tension springs will fill the looper from the supply reel. The processor is inhibited during photography, causing the film transport components past the camera storage looper to remain idle.

Inadvertent Commands - The consequences of inadvertent commands during photography are:

(1) SPC-1 (V/H ON command) is ignored during a photographic sequence.
(2) SPC-3 (read-out electronics ON command) will activate the read-out electronics and terminate the photographic sequence.
(3) SPC-4 (V/H OFF command) is used as a back-up camera OFF command. Therefore, if it is given during photography, the sequence will be terminated.
(4) RTC-5 (read-out drive ON command) if not preceded by SPC-3 (read-out electronics ON) will not activate the read-out drive. However, RTC-5 will set the read-out release memory (a memory which inhibits the processor, and the read-out release clutch), thereby forcing the processor to remain inhibited after the photographic sequence is complete until RTC-16 (wind forward command) is given.
(5) RTC-6 (read-out drive OFF command) will have no effect if given during a photographic sequence.

(6) RTC-8 (Bimat cut) will set the Bimat-cut memory. If the Bimat-cut memory is not cleared with RTC-16 (wind forward command) before processing is resumed, the Bimat cutter will be activated when processing is resumed, ending processing and the photographic portion of the mission.

(7) RTC-16 (wind forward command) will have no effect during photography.

(8) SPC-18 (solar eclipse ON) will terminate the photographic sequence.

(9) SPC-19 (solar eclipse OFF) will have no effect during photography.

(10) SPC-26 (fast camera rate) will be ignored if given during a photographic sequence.

(11) SPC-27 (slow camera rate) will change the camera rate if given during a fast camera rate sequence. No change will occur if the slow camera rate is already in process.

(12) SPC-28 through 31 (Frame Count) if given during a sequence, can result in an indeterminate number of frames limited by the specific frame count commanded and the capacity of the camera storage looper.

2.3.2.2 V/H Mode. The mode of PS operation when the V/H sensor is operating is referred to as the V/H mode; however, the V/H mode, with respect to the CCP, is defined as the mode of operation when the V/H memory is ON.

The V/H sensor is activated by application of ±20-volt power. SPC-1 (V/H ON) sets the V/H memory in the CCP. The output of this memory switches the 20-volt source to the V/H sensor with CAS-4 (V/H relay state) and, after a nominal 12 millisecond delay, enables the 20-volt converter with CAS-17 (±20- and +6.3-volt converter ON/OFF). At the end of a photo sequence or when SPC-4 (V/H OFF) is given, the V/H memory is reset and the 20-volt converter is disabled. When the V/H sensor is turned OFF, the intervalometer shaft encoder (which is driven by the V/H sensor output cam) will stop in a position where the DV and CF switch will be closed. There is no film transport associated with the V/H mode other than when the V/H sensor is used for photography.

Inadvertent commands - all inadvertent commands other than SPC-3, RTC-8, and SPC-18 have no effect on V/H operation. Command SPC-2 will result in a transition to the photographic mode. SPC-3 (read-out electronics ON) will activate the read-out electronics as well as clear the V/H memory. The effect of RTC-8 (Bimat cut) will be the same as discussed in the photographic mode. SPC-18 (solar eclipse ON) will clear the V/H memory, turning the sensor OFF.

2.3.2.3 Processing Mode. The processing mode refers to the mode of PS operation when the Bimat drive is operating, and processor and dryer heaters are enabled (before the Bimat-cut command is given.)

The Bimat drive and the processor and dryer heaters are inhibited by:

a) Camera Memory ON (during a photographic sequence).
b) Read-out electronics-memory ON (during read-out mode).
c) Solar eclipse memory ON (during solar eclipse).
d) V/H Memory ON (during V/H mode).
e) Bimat clear condition.
f) Camera storage looper empty condition.
g) Read-out release memory (when the read-out drive ON command RTC-5) has occurred later than the wind forward (RTC-16 command).

When none of the above conditions occur, processing is enabled. During the processing mode the film transport between the supply and the camera storage looper is idle. When the Bimat drive is ON, the read-out release clutch is disengaged. The take-up motor will turn ON in the forward direction when the read-out looper has reached the R/O looper partial full condition. This condition is determined by a switch located such that only about 2 to 3 inches of processed film enters the R/O looper in the forward direction before the take-up motor operates and empties the R/O looper.

Inadvertent commands - All commands may be given except RTC-8 (Bimat cut). If RTC-8 (intentional or inadvertent) is given during processing, the Bimat cut operation will start. RTC-16 (wind forward) and RTC-6 (read-out drive OFF) can be given, but will have no effect.

2.3.2.4 Processing Standby Mode. The processing standby mode refers to the mode of PS operation when processing could occur but there is no film in the camera storage looper to be processed.

When all the film in the camera storage looper has been processed the camera-looper empty condition will inhibit processing. In this mode, the film transport will be inactive.

Inadvertent Commands - All commands may be given except RTC-8. As in the processing mode, RTC-6 and RTC-16 can be given but will have no effect.

2.3.2.5 Quick-Look Read-Out Standby Mode. The quick-look read-out standby mode refers to the mode of PS operation when processing could occur but is inhibited by the read-out release memory and read-out is not taking place. Inhibiting the processor and thus keeping the read-out release clutch engaged allows quick-look read-out to be stopped without subsequent movement of film through the read-out gate until resumption of R/O or termination of this mode.

The read-out drive ON command (RTC-5) clears the read-out release memory. This inhibits the processor and engages the read-out release clutch. In this mode the film transport is idle. Because processing can be inhibited by either the read-out release clutch inhibit and/or the camera-storage-looper empty condition, processing standby and quick-look read-out standby modes can occur simultaneously. Although this standby mode is associated with read-out it can be used to inhibit processing at any time. Because the read-out electronics must be ON before the read-out drive can be activated, RTC-5 (read-out drive ON) can be used to inhibit processing directly without influencing the read-out.

Inadvertent Commands - All commands may normally be given in this mode except RTC-6 (R/O Drive OFF) and RTC-8 (Bimat Cut). If RTC-8 is given, the Bimat-cut memory is set. RTC-16 (wind forward) must be given to resume processing; the Bimat-cut memory will be cleared by RTC-16. RTC-6 will have no effect if given.

2.3.2.6 Read-Out Modes. There are two read-out modes: (1) quick-look read-out mode, and (2) final read-out mode. The quick-look read-out mode is defined with respect to the CCP as the mode of PS operation when the read-out electronics memory is ON or the spot-stop switch is open, and the Bimat has not been cut. The final read-out mode is defined as the mode of PS operation when the read-out electronics memory is ON or the spot-stop switch is open, and the Bimat has been cut and cleared past the processing drum.

Read-out is initiated with SPC-3 (read-out electronics ON) which sets the read-out electronics memory (and also inhibits the processor, V/H sensor, and the camera). The output of this memory enables the LST anode motor signals (MS-9, MS-10, MS-11, MS-12) and switches the ±20- and +6.3-volt source relay to the read-out electronics with CAS-10. A nominal 10 milliseconds after CAS-10 switches the ±20- and 6.3-volt source relay, CAS-17 enables the ±20- and 6.3-volt converter. Nominally 20 seconds after CAS-10 switches the source relay, CAS-20 turns the high-voltage converter ON. When RTC-5 (read-out drive ON) is given, the optical-mechanical scanner (OMS) drive is activated and will move the scanning optics a short distance to the focus stop position near the edge of the film. The OMS drive has then clamped the film in the read-out gate. The OMS will automatically stop in the focus stop position where focus and photo video gain adjustments can be made.

When the read-out adjustments are complete the OMS drive is activated with a second RTC-5 command (read-out drive ON). The read-out mode is terminated with RTC-6 (read-out drive OFF). RTC-6 resets the read-out electronics memory; however, the memory output is gated with the spot-stop switch input so the read-out electronics do not turn OFF until the OMS is in the film unclamped position on the edge-date side of the film (that is, the OMS drive cam stops so as to free the film in the read-out gate). The read-out drive OFF command turns OFF both read-out electronics and read-out drive.

The quick-look and final read-out modes vary only in the film transport from the supply reel to the read-out looper. In both read-out modes the take-up will drive film from the take-up reel into the take-up looper, turning ON when the take-up looper becomes empty and turning OFF when the take-up looper becomes full (as the read-out continues). In the quick-look read-out mode the film transport from the supply reel to the read-out looper will be idle. When quick-look read-out takes place, the processor is inhibited so the transport will remain idle. When final read-out takes place, the processor is free wheeling (because the Bimat has been cut and removed from the film path) and the film will accumulate in the read-out looper. If the read-out looper should fill, film will then accumulate in the camera storage looper. When the read-out is turned OFF film is pulled into the supply reel by the supply spool drive motor until both of these loopers are empty.

All heaters will be inhibited during the read-out modes.

Inadvertent Commands - SPC-1 (V/H ON command) will be ignored if given during read-out.

SPC-2 (camera ON command) if given during read-out, will terminate read-out but will not activate the camera, unless the command was given when the OMS was in the spot-stop position at the edge of the film. However, the OMS will move to the spot-stop position if not there when SPC-2 is given, before the OMS drive shuts OFF. If SPC-2 is received when OMS is in the spot-stop position (the probability of this occurring is very small) the read-out will be terminated immediately and the camera will be activated.

SPC-4 (V/H OFF) will have no effect during read-out becuase the V/H is already OFF, being inhibited during read-out.

RTC-8 (Bimat cut) will set the Bimat-cut memory. Because RTC-16 must be used to clear the Bimat-cut memory and set the read-out release memory before processing can be resumed, RTC-8 will have no effect during this read-out mode.

RTC-16 (wind forward) will set the read-out release memory; in this manner, when read-out is terminated in the quick-look mode (by RTC-6, R/O drive OFF), processing or processing standby will be resumed.

SPC-18 (solar eclipse ON) will terminate read-out into one of the two read-out standby modes, depending on which mode was in process when SPC-18 was received.

SPC-19 (solar eclipse OFF) and SPC's 26 through 31 will have no effect if given during read-out.

2.3.2.7 <u>Final Read-out Standby Mode.</u> The final read-out standby mode is defined as the mode of PS operation when the Bimat is clear, the wind-forward memory is OFF, and the spot-stop switch is closed. These conditions represent the PS state between periods of final read-out.

During the final read-out standby mode the processor is free wheeling and the camera advance motor operates in the reverse direction. Film is removed from the read-out and camera storage loopers by the reversed camera-advance motor. Film is run into the supply looper which takes up the film via its tension springs until the looper full switch is actuated, turning on the supply motor which empties the supply looper. The supply looper will be filled by the camera drive and emptied by the film-supply drive in a cyclic manner until the read-out and camera loopers are both empty.

Inadvertent Commands - SPC-1 (V/H ON), SPC-4 (V/H OFF), RTC-5 (read-out drive ON), RTC-6 (read-out drive OFF), RTC-8 (Bimat cut), SPC-19 (solar eclipse OFF), RTC-16 (wind forward), and SPC's-26 through 31 will not affect the final read-out standby mode. SPC-1 (V/H ON) will, however, turn ON the V/H sensor.

SPC-2 (camera ON) given during final read-out standby will initiate the wind forward mode and inhibit the reverse camera film drive.

SPC-3 (read-out electronics ON) if given during final read-out standby will initiate read-out and inhibit the reverse camera film drive.

SPC-18 (solar eclipse ON) will inhibit the reversed camera film drive and the supply drive.

2.3.2.8 Bimat-Cut Mode. The Bimat-cut mode refers to the mode of PS operation from the time Bimat cut is initiated with RTC-8 (Bimat-cut command) until the Bimat clears the processing drum.

When RTC-8 (Bimat cut) is given it is stored in the Bimat-cut memory. The output of the Bimat-cut memory will be inhibited unless the Bimat-cut roller is in a position to ensure a complete cut. The output of the Bimat-cut memory is gated with the Bimat drive such that the processor

must be operating or power will not be applied to the hot-wire cutter. When the cutting process is complete the Bimat-cut OFF switch input will clear the Bimat-cut memory turning OFF power to the hot wire. The Bimat drive will continue until the Bimat has cleared the processing drum at which time the Bimat clear switch input will inhibit the Bimat drive and processor-dryer heaters for the remainder of the mission. All heaters are inhibited while the Bimat-cut memory is set.

The film transport during the Bimat-cut mode is the same as during the processing mode until the Bimat-clear switch is activated. When the Bimat-clear switch opens the film transport will be reversed, as in the final read-out standby mode.

Inadvertent Commands - SPC-1 (V/H ON), SPC-2 (camera ON), SPC-3 (read-out electronics ON), RTC-5 (read-out drive ON), and SPC-18 (solar eclipse ON) will inhibit the Bimat drive and, will therefore inhibit the Bimat-cut mode.

SPC-4 (V/H OFF), RTC-6 (read-out drive OFF), SPC-19 (solar eclipse OFF) and SPC's-26 through 31 will not affect the Bimat-cut mode.

RTC-16 (wind forward) will clear the Bimat-cut memory. If RTC-16 occurs before the Bimat cut is completed the Bimat-cut operation will be interrupted and terminated. If RTC-16 occurs after the Bimat has been cut it will have no effect.

2.3.2.9 <u>Wind-Forward Mode.</u> The wind-forward mode refers to the mode of PS operation after Bimat clear when the transport logic is switched to the forward direction via the wind-forward memory.

In the wind-forward mode the processor is free wheeling and the read-out release clutch is disengaged. The film take-up drive will be ON in the forward direction when the camera storage and read-out loopers

are not empty. Film is advanced through the camera by operating the camera as it was operated in the photographic mode. The wind-forward mode is initiated with SPC-2 (camera ON) and terminated with RTC-8 (Bimat cut). The names of some commands will have become misnomers resulting from their use for more than one function and from changes of their functions. When RTC-8 is used before Bimat is clear, it functions as a Bimat-cut command; but, when used after the Bimat is clear, it clears the wind-forward memory.

Inadvertent Commands - SPC-1 (V/H ON), SPC-4 (V/H OFF), (read-out drive ON), RTC-6 (read-out drive OFF), RTC-16 (wind forward) SPC-19 (solar eclipse OFF) and SPC's 26 through 31 will have no effect on the wind-forward mode.

SPC-3 (read-out electronics ON) if given during wind forward will activate the read-out electronics, but will not terminate the mode. RTC-8 must be given to allow the read-out drive to operate, terminating the wind forward mode.

2.3.2.10 <u>Solar Eclipse.</u> The solar eclipse mode is defined with respect to the CCP as the mode of PS operation when the solar-eclipse memory is ON.

SPC-18 (solar eclipse ON) and SPC-19 (solar eclipse OFF) set and clear the solar-eclipse memory. The set condition of this memory provides inhibition signals to the logic which controls PS operations to ensure a minimum power drain. (See paragraph 2.5 for the functions which are inhibited).

### 2.3.3 Mode to Mode Transitions

#### 2.3.3.1 Normal Transitions

a. Transitions from the V/H and photographic modes - Normal transitions from the V/H and photographic modes are shown in Figure 2-28.

V/H and/or photographic to processing mode - When the V/H sensor and/or camera are turned OFF by conditions other than SPC-18 (solar eclipse ON) or SPC-3 (read-out electronics ON) and the camera storage looper is not empty and the read-out release memory is not set (power turn-on or RTC-16 has occurred later than RTC-5) the processor will be enabled.

V/H or photographic mode to quick-look read-out standby mode - When the V/H and/or camera are turned OFF by conditions other than SPC-18 (solar eclipse ON) or SPC-3 (read-out electronics ON) and the read-out release memory is set (RTC-5 has occurred later than RTC-16), the transition from V/H and/or photographic to quick-look read-out standby mode will occur.

V/H and/or photographic mode to solar eclipse mode - SPC-18 (solar eclipse ON) when given while the V/H sensor and/or camera are ON, will turn them OFF, causing the transition from V/H and/or photographic to solar-eclipse mode.

V/H mode to processing standby mode - When the V/H mode is terminated by conditions other than SPC-3 (read-out electronics ON) or SPC-18 (solar eclipse ON), the read-out release memory is not set (RTC-16 has occurred later than RTC-5), and the camera storage looper is empty, the transition from V/H to processing-standby mode will occur.

b. Transitions from the processing mode - The eight possible transitions from processing (see Figure 2-29) can be associated with the inhibit signals to the Bimat drive and processor and dryer heaters. The Bimat drive,and processor and dryer heaters are inhibited by the following:

(1) V/H memory (processing mode to V/H mode)
(2) Camera memory (processing mode to photographic mode)
(3) Read-out electronics memory (processing mode to quick-look read-out mode)
(4) Solar-eclipse memory (processing mode to solar-eclipse mode)

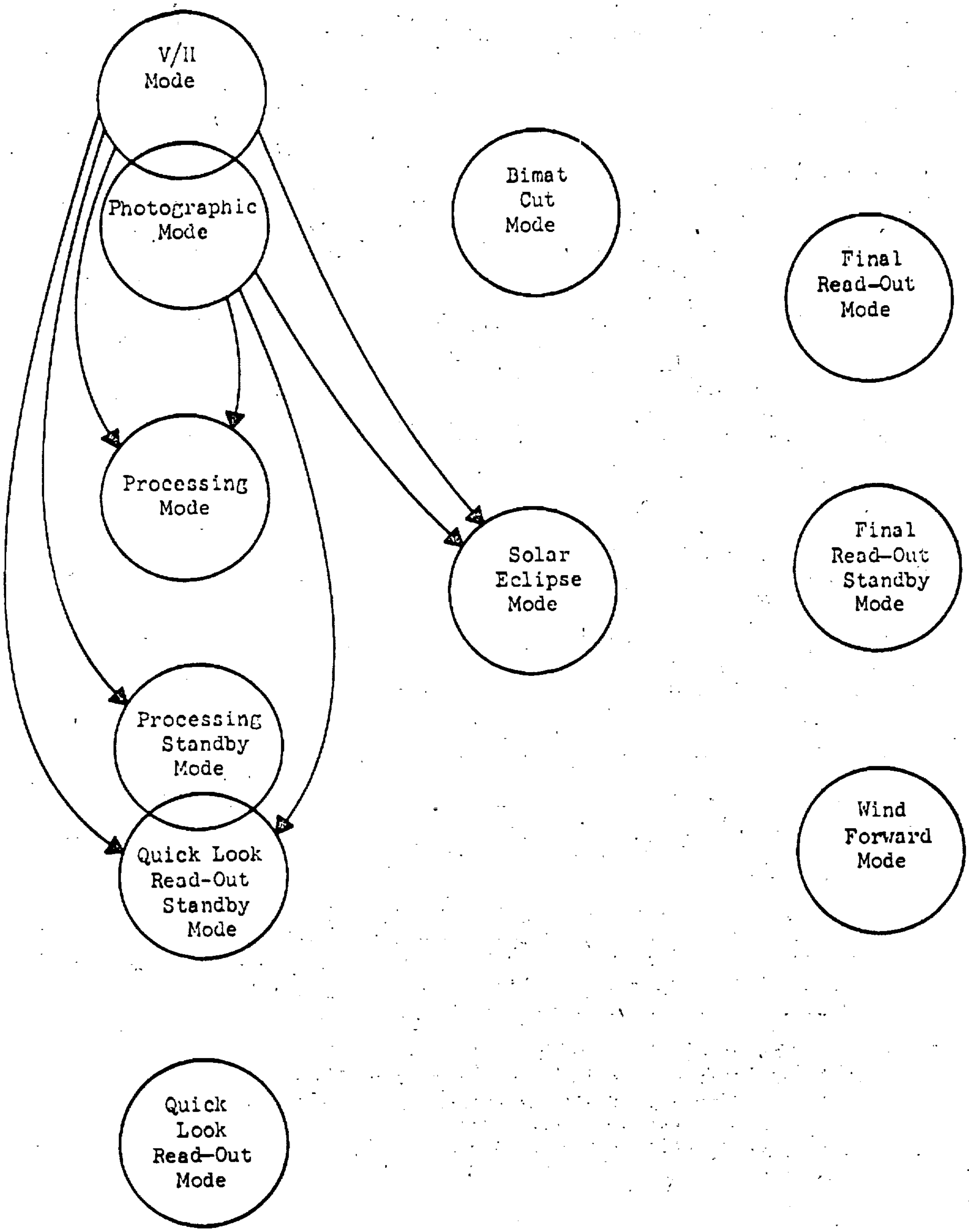



Figure 2-28. Normal Flow of Operation From V/H and/or Photographic Mode

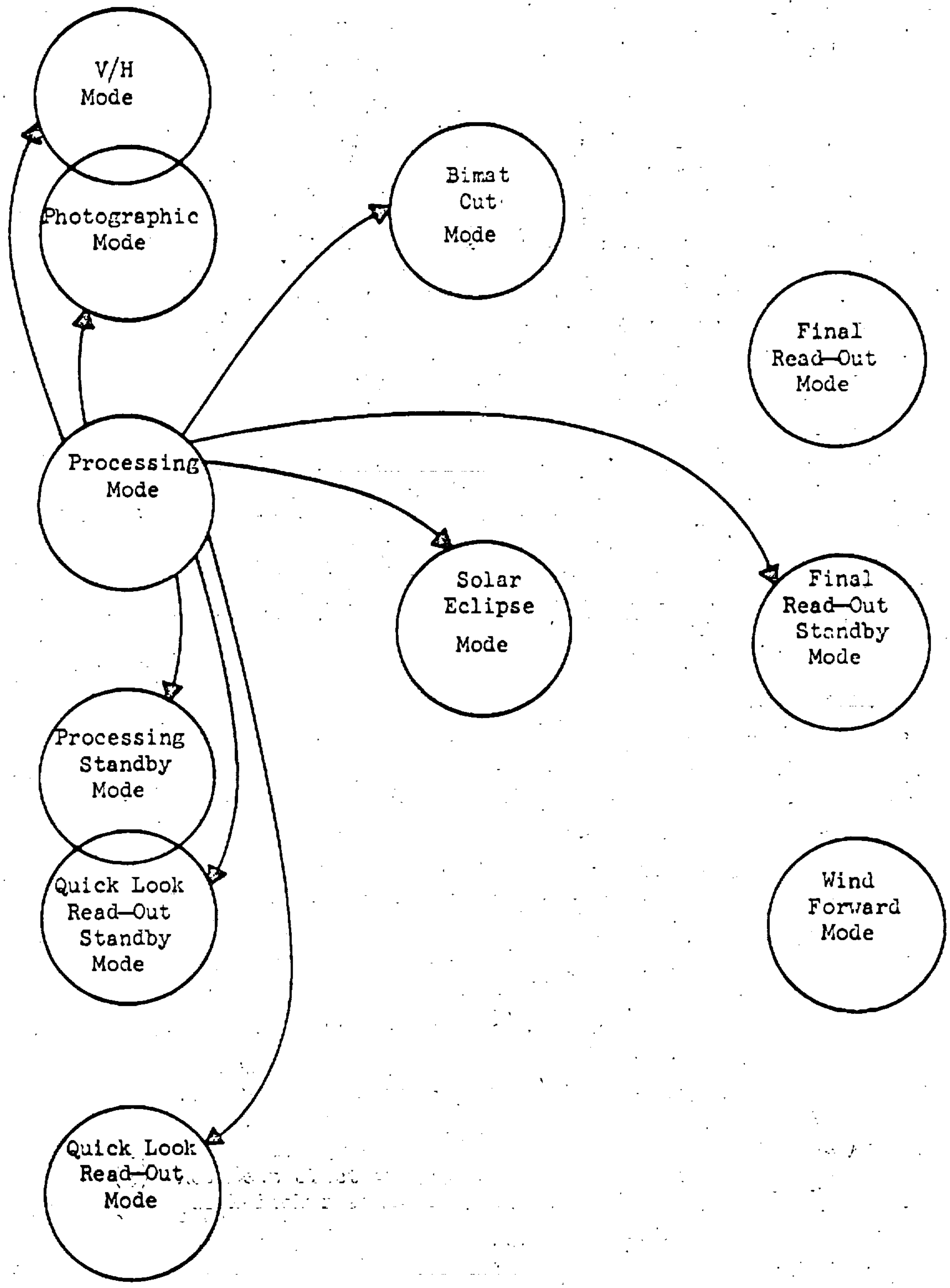



Figure 2-29. Normal Flow of Operation From Processing

(5) Camera storage-looper empty condition (processing mode to processing-standby mode)
(6) Read-out release memory (processing mode to quick-look read-out standby)
(7) Bimat clear condition (processing mode to final read-out standby mode)
(8) In the Bimat-cut mode the processor and dryer heaters are inhibited but the Bimat drive is operating. RTC-8 (Bimat cut) initiates Bimat cut; however, because the Bimat cut is gated with the Bimat drive, the cutting operation does not occur until the Bimat drive is enabled.

c. Transitions from processing standby and/or quick-look read-out standby modes - The processing standby and quick look read-out standby modes are quiescent modes. A transition is possible from these standby modes to any other mode that occurs before Bimat cut or Bimat clear, with one exception (See Figure 2-30). The exception is processing standby to processing. In processing standby the camera storage looper is empty; therefore, processing cannot resume until a photographic sequence has occurred. The transitions can be associated within the following commands:

SPC-1 (V/H ON) processing standby and/or quick-look read-out standby to the V/H mode.

SPC-2 (camera ON) processing standby and/or quick-look read-out standby to photographic mode.

SPC-3 (read-out electronics ON) processing standby and/or quick-look read-out standby to quick-look read-out mode.

RTC-16 (wind forward) quick-look read-out standby to processing mode, if camera storage looper is not empty.

SPC-18 (solar eclipse) processing standby and/or quick-look read-out standby to solar eclipse mode.

d. Transitions from the quick-look read-out mode - The normal transitions from quick-look read-out are shown in Figure 2-31.

Quick-look read-out to quick-look read-out standby mode - RTC-6 (read-out drive OFF) given during quick-look read-out will clear the read-out electronics memory. With the read-out electronics memory cleared, the optical mechanical

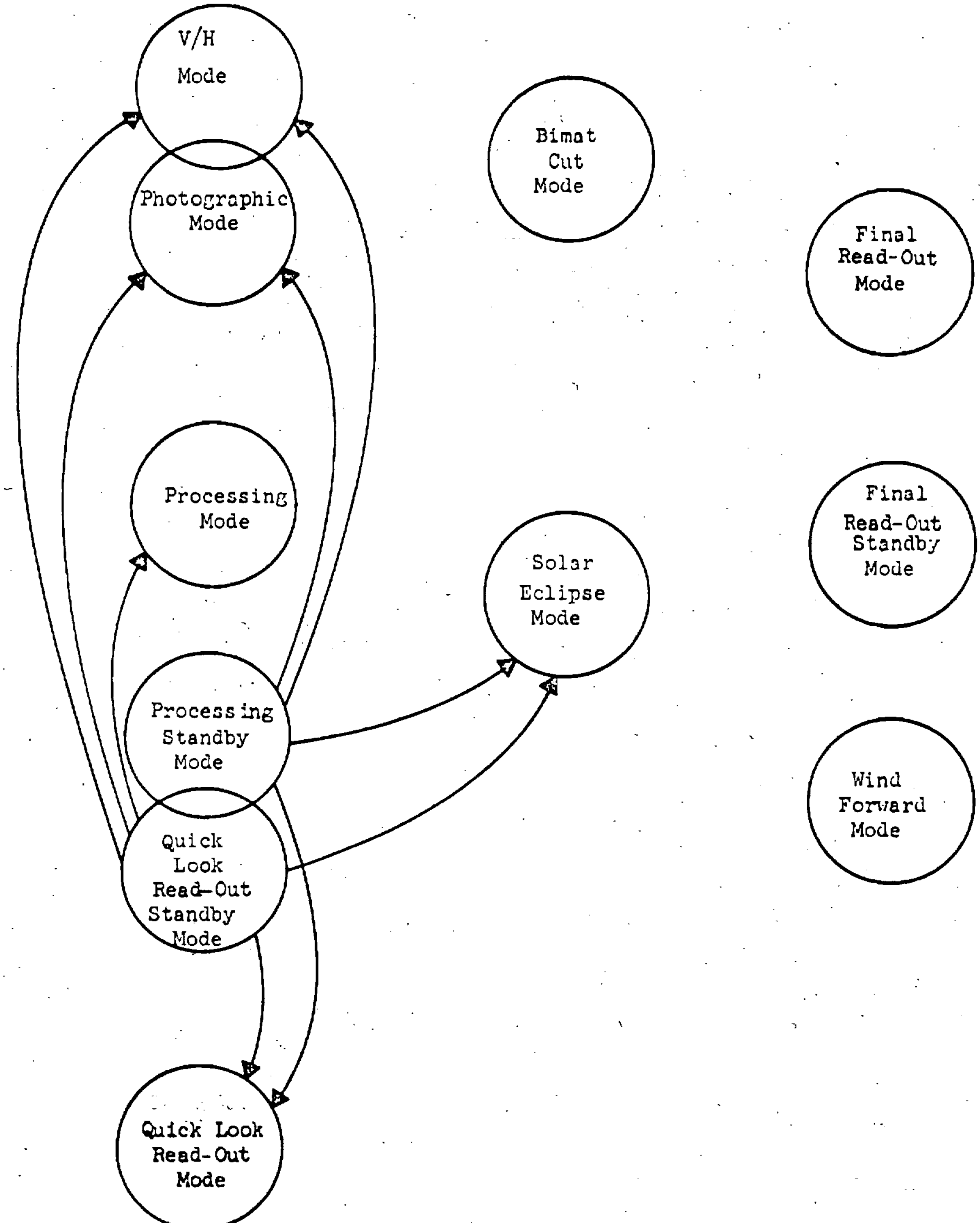



Figure 2-30. Normal Flow of Operation From Processing and/or Quick Look Read-Out Standby Modes

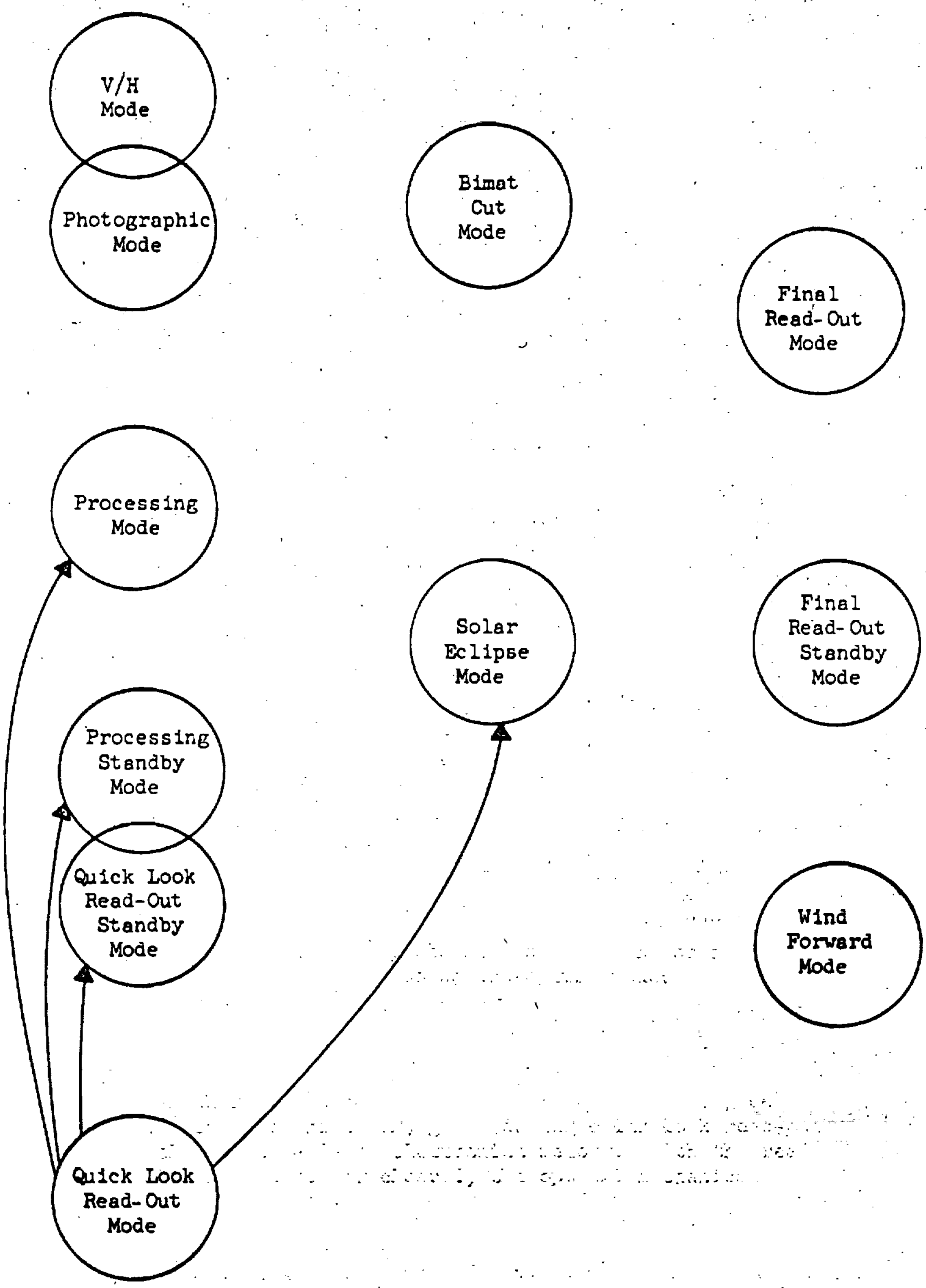



Figure 2-31. Normal Flow of Operation From Quick Look Read-Out

scanner will continue to the spot-stop position. When the spot-stop switch is closed the read-out electronics and drive will be turned OFF. If RTC-5 (read-out drive ON) has occurred later than RTC-16 (wind forward) the read-out release memory will be cleared, engaging the read-out clutch, and therefore the logic will be in the quick-look read-out standby mode.

Quick-look read-out to processing standby mode - If the read-out looper becomes full, read-out will be terminated, and the read-out release memory will be set. Thus, if the camera storage looper is empty, the quick-look read-out to processing standby transition will occur.

Quick-look read-out to processing mode - If the camera storage looper is not empty when the read-out looper becomes full, read-out will be turned OFF, the read-out release memory will be set, and therefore, the logic will be in the processing mode.

Quick-look read-out to solar eclipse mode - SPC-18 (solar eclipse ON) will clear the read-out electronics memory. With the read-out electronics memory cleared, the optical-mechanical scanner will continue to the spot-stop position. When the spot-stop switch is closed the read-out electronics and drive will be shut OFF.

e. Mode to mode transitions after Bimat clear - As the Bimat clear is an irreversible operation, the Bimat cut and clear event divides the PS operation into two parts. The mode to mode transitions occurring after Bimat clear are shown in Figure 2-32. Actuation of the Bimat clear switch keys the transition from Bimat cut to final read-out standby mode. Since the processor is inhibited by solar eclipse, and the processor must run to cut and clear the Bimat, it is important to perform Bimat cut such that adequate time is available for Bimat clear to occur prior to solar eclipse. Transitions between Bimat cut and solar eclipse modes can, in this manner, occur. Mode to mode transitions after the Bimat clear can be associated with the following commands:

SPC-3 (read-out electronics ON) final read-out standby to final read-out mode.

RTC-6 (read-out drive OFF) final read-out to final read-out standby mode.

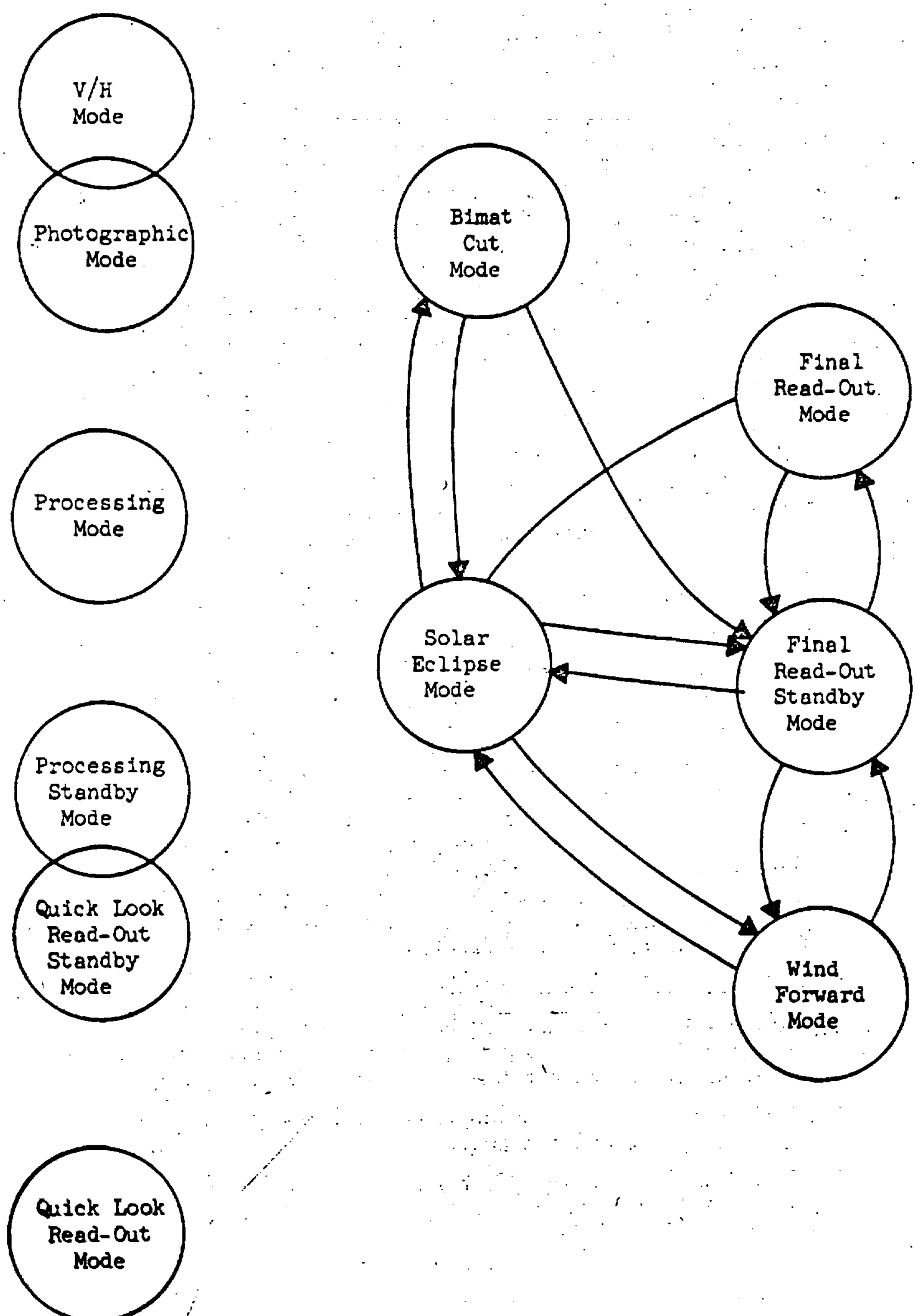



Figure 2-32. Normal Flow of Operation After The Bimat Clears The Processor

SPC-2 (camera ON) final read-out standby to wind-forward (toward the take-up) mode.

RTC-8 (Bimat cut) wind forward to final read-out standby mode.

SPC-18 (solar eclipse ON) final read-out, final read-out standby or wind forward to solar eclipse mode.

SPC-19 (solar eclipse OFF) solar eclipse to final read-out standby or wind-forward modes.

f. Transitions from solar eclipse - SPC-18 (solar eclipse ON) sets the solar-eclipse memory. The output of the solar-eclipse memory inhibits: V/H, camera, processor (includes processor/dryer heaters), take-up drive, supply drive and supply brake, camera film advance, and all heaters not enabled during solar eclipse. The read-out clutch remains engaged. After Bimat clear, solar eclipse has no effect on the processor, which is permanently inhibited.

SPC-18 terminates the V/H and/or photographic mode and the read-out mode by clearing their respective memories. Therefore, when the solar eclipse memory is cleared with SPC-19, these modes will not be resumed automatically (see Figure 2-33). Transitions from solar eclipse will occur under the following conditions: When SPC-19 (solar eclipse OFF) occurs while the read-out release memory is cleared (RTC-5 has occurred later than RTC-16), the camera storage looper is not empty, and the Bimat is not clear, the quick-look read-out standby mode will be resumed. When SPC-19 occurs while the read-out release memory is set (RTC-16 has occurred later than RTC-5), the Bimat is not clear and the camera storage looper is not empty, processing will be resumed. When SPC-19 occurs while the Bimat is not clear, the camera storage looper is empty, and the read-out release memory is set (RTC-16 has occurred later than RTC-5), processing standby will be resumed. When SPC-19 occurs while the Bimat is clear and the wind-forward memory is not set (RTC-8 has occurred later than SPC-2 and Bimat clear), final read-out standby is resumed. When SPC-19 occurs while the Bimat is clear and the wind-forward memory is set (SPC-2 and Bimat clear has occurred later than RTC-8) the wind-forward mode will be resumed.

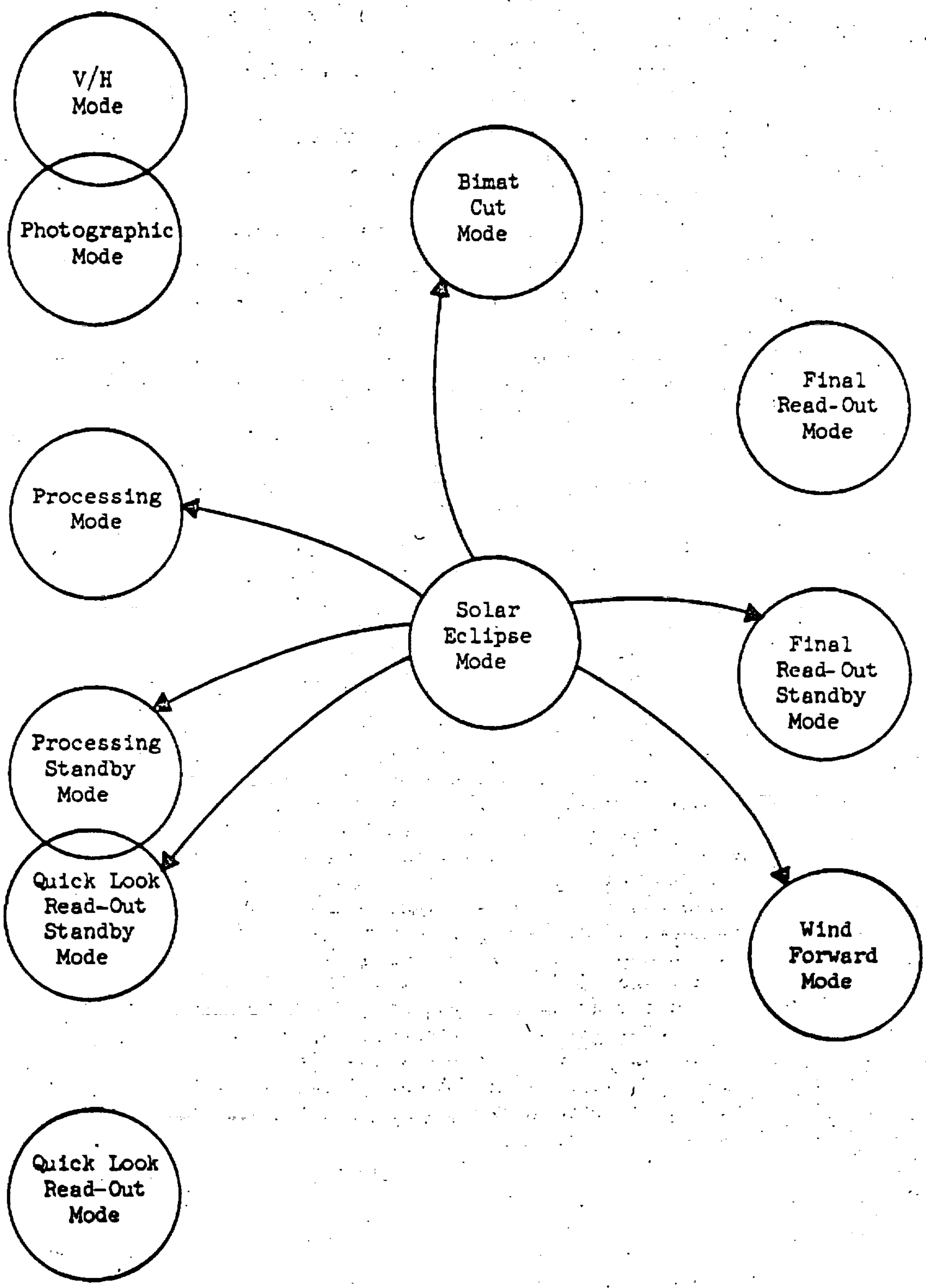



Figure 2-33. Normal Flow of Operation From Solar Eclipse

2.3.3.2 Abnormal Mode to Mode Transitions. Some possible transitions that are considered abnormal are shown in Figure 2-34.

a. V/H and/or Photographic Modes to Quick-Look Read-Out Mode - If SPC-3 (read-out electronics ON) is given during V/H and/or photographic modes they will be turned OFF and quick-look read-out will be initiated.

b. Quick-Look Read-Out to Photographic Mode - If SPC-2 (camera ON) is given during quick-look read-out when the optical-mechanical scanner is in the spot-stop position, the read-out will be turned OFF and a photographic sequence initiated. If SPC-2 is given during quick-look read-out when the optical-mechanical scanner is not in the spot-stop position the read-out will be turned OFF, but the photographic sequence will not be initiated. A quick-look standby mode will follow the read-out.

   Because Bimat cut is inhibited when the Bimat drive is inhibited, transition from Bimat cut to V/H, photographic, processing, processing standby, quick-look read-out, or quick-look read-out standby are possible. None of the Bimat drive inhibitions will normally occur during the Bimat-cut mode.

c. Final Read-Out Standby or Wind Forward to V/H Mode - If SPC-1 (V/H ON) is given during final read-out standby or wind forward (when the camera is inactive) the V/H sensor will be turned ON. The transport logic will remain unchanged through either of these transitions.

d. Final Read-Out to Wind Forward Mode - If SPC-2 (camera ON) is given during final read-out when the OMS is in the spot-stop position the read-out will be terminated and wind forward will be initiated. If SPC-2 is given during final read-out when the OMS is not in the spot-stop position, read-out will be terminated but wind forward will not be initiated.

   Although the abnormal mode to mode transitions do not yield catastrophic results, they should be avoided in the mission program as they do yield some undesirable results. The undesirable results that might occur are EMI generation and periods of time when the PS state is unknown. For these reasons the mode to mode transitions shown in Figure 2-34, should not occur in a normal mission.

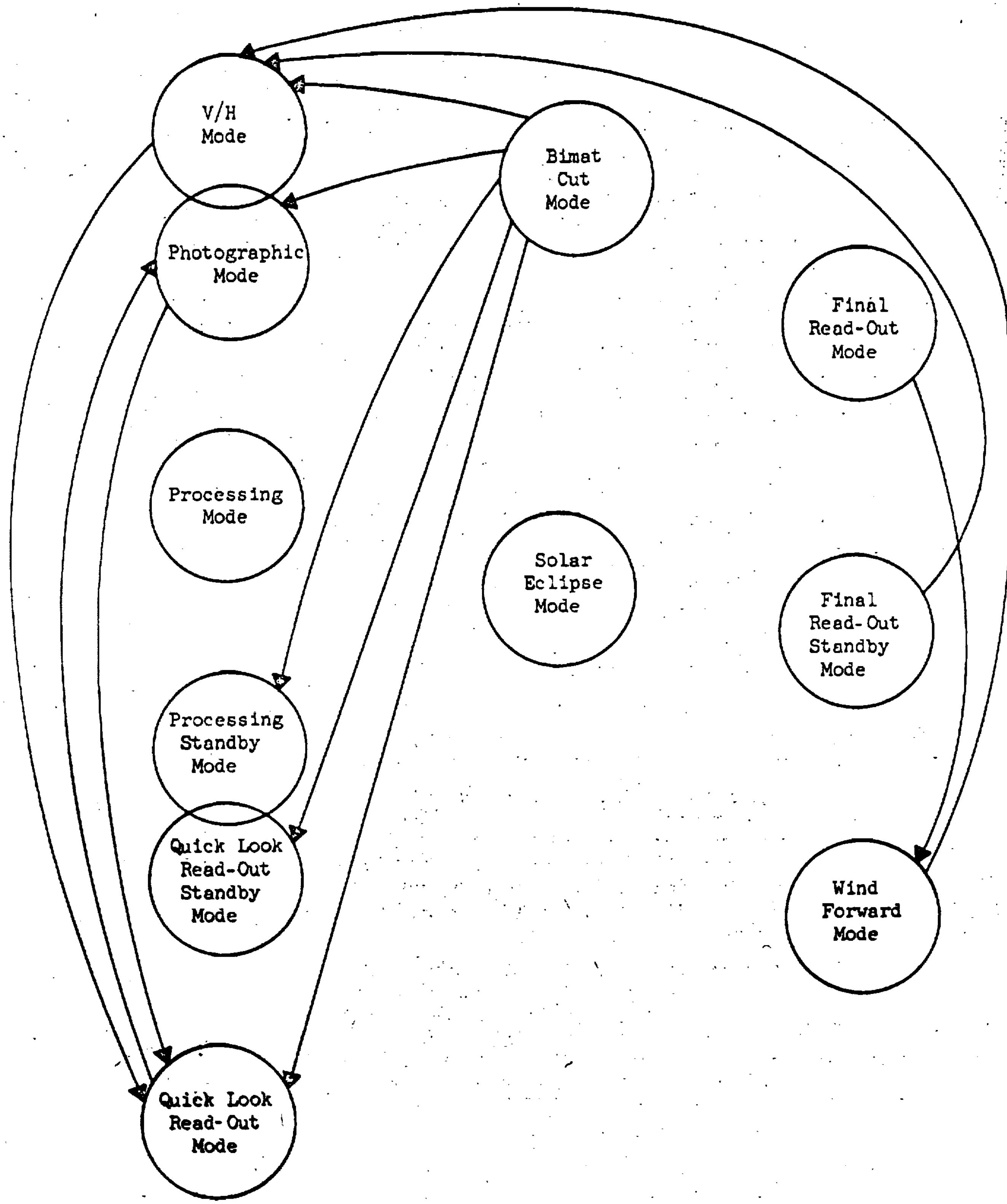



Figure 2-34. Abnormal Flow of Operation

2.3.4 Some PS Programming Considerations

2.3.4.1 Transition Between the Processing and Read-Out Modes. There is a small but finite possibility that the take-up drive directional relay will fail to switch from forward to reverse in going from a processing to read-out mode. This situation could occur because the read-out looper partial full condition is randomly related in time to a read-out electronics ON and take-up looper EMPTY condition, and because the take-up drive relay switching circuit requires time to recharge its storage capacitor. The directional error possibility can be eliminated by inhibiting processing a minimum of 500 milliseconds before the read-out electronics are commanded ON. This can be accomplished by executing RTC-5 (read-out drive ON) at least 500 millisecond prior to the execution of SPC-3 (read-out electronics ON) when initiating limited read-out during or immediately after a processing cycle.

2.3.4.2 Application of PS Power When Bimat is Clear, During Ground Testing. Power is applied to the PS prior to launch and is not interrupted prior to completion of final read-out in a normal mission. However, during the test program prior to launch, it may become necessary to interrupt PS power. Power interruption when the PS is in final read-out mode, after Bimat clear, can cause film transport problems. Two problems could occur (1) an ambiguity in camera film-drive direction and (2) an ambiguity in take-up reel drive direction. These problems are partially caused by the charging time of capacitors associated with the latching relay circuits which control film-drive direction in the camera and take-up mechanisms.

Upon application of power in a Bimat clear state, the PS is immediately placed in a solar-eclipse ON state which prevents all film transport operations. As a result of transient conditions during turn-off, or if

the PS was in a wind forward mode prior to power turn-off, the camera film transport direction latching relay could be placed in a forward direction. Though the logic on the encoder will be in a reverse sense, the latching relays could be latched in the forward direction. Thus, if solar eclipse is commanded OFF, and there is film in the camera and read-out storage loopers, the camera film advance can come ON in the forward direction emptying the supply looper. However, the logic expects the camera to fill the supply looper and this status cannot be achieved. Therefore, the camera film-advance motor will stall out. To ensure maximum turn-on reliability, it is recommended that the camera and read-out storage loopers be empty at the time of power turn-off. In any event, due to film stretch or creep, it is still necessary to command camera ON (SPC-2) prior to the solar-eclipse OFF command (SPC-19). The camera ON command (SPC-2) switches the PS logic into the wind-forward mode for the 50-millisecond duration of the command pulse. This momentary signal is sufficient to re-establish logic and latching relay status because logic and latching relays will switch to the reverse direction on the trailing edge of the camera ON (wind forward) pulse.

A similar situation to the camera film-advance problem can exist with the take-up reel. When power is applied the take-up looper memory could come ON in an empty-before-full state or a full-before-empty state. If the memory is in an empty-before-full state, the take-up motor will come on when solar-eclipse OFF (SPC-19) is commanded. If the take-up direction relay is latched in the forward direction, the take up will come on emptying the take-up looper. However, the looper logic will be in a read-out mode as a result of the Bimat-clear indication, demanding that a take-up looper FULL condition be established. Because the take-up motor is operating in the forward direction, emptying the take-up looper, this requirement cannot be fulfilled, and the take-up motor will stall out.

If both the camera storage and read-out loopers are empty before power interruption, a camera ON command (SPC-2), given prior to solar-eclipse OFF (SPC-19), will re-establish both take-up looper logic and drive direction on the trailing edge of the 50-millisecond command pulse. However, if the camera and read-out storage loopers are not empty, another situation exists.

When loopers are not empty, the take-up logic will switch to the forward direction on the leading edge of the camera ON (SPC-2) command pulse if it is in the correct or reverse direction. The take-up logic will then switch back to the reverse direction on the trailing edge of the command pulse. However, the time constant of the relay circuit is longer than 50 milliseconds and this second switching will not be accomplished.

It can be seen from the above discussion that giving SPC-2 prior to SPC-19 is not a complete solution to the take-up reel problem. Even though loopers can be emptied prior to power turn OFF, film creep or stretch can be sufficient to cause an appearance of storage looper <u>not</u> <u>empty</u> conditions.

The solution to the take-up reel problem is to give the camera ON (SPC-2) command again, immediately after solar-eclipse OFF (SPC-19). The possibility still exists that the take-up reel will stall out; however, the length of the stall period will be limited to the time interval between solar-eclipse OFF (SPC-19) and the camera ON command (SPC-2) which follows it.

In view of the situations described above, the following steps are recommended for any power interruption during testing when the PS is in the final read-out mode (Bimat clear status).

a. Empty both camera storage and read-out loopers before power turn-off.

b. After power turn-on and before solar-eclipse OFF (SPC-19), give a camera ON command (SPC-2).

c. Give a solar-eclipse OFF command (SPC-19).

d. Immediately after step c, give a second camera-ON command (SPC-2).

The above steps will prevent all but a momentary stall condition on the take-up reel.

2.3.4.3 Bimat Cut. It will be necessary to wind-forward one frame after the Bimat clears the processor. When the Bimat has cleared the processor, the film transport-logic controls the camera film drive and supply drive to pull film from the camera and read-out loopers until empty. Because in the Processing/Bimat cut mode prior to Bimat clear the take-up drive turns on when read-out looper is partially full, and turns off when the read-out looper becomes empty, after the Bimat has cleared, a length of film (up to the amount of film between the read-out empty and partially full switch) will be pulled back on the processing drum.

The film that would be pulled back on the processor drum will be wet, and must be advanced onto the dryer drum before it adheres to the processor drum. To accomplish this, the SPC-2 (camera ON) will have to be executed (within minutes after Bimat clear occurs*) to advance the film onto the dryer drum.

2.3.4.4 Program to Ensure Against Inadvertent Bimat Cut. The following programming technique is recommended to ensure against inadvertent Bimat cut. The process uses RTC-16 (wind-forward ON) as a clearing signal for

* To be determined by test

the Bimat-cut command memory. Because Bimat cut cannot occur unless the PS is processing, there are long periods in the mission when an inadvertent Bimat-cut command will not be catastrophic, if the Bimat-cut command memory is cleared prior to the next processing cycle. Possible transitions to the processing mode include:

a. V/H and/or photographic to processing mode.
b. Quick-look read-out to processing mode.
c. Quick-look read-out standby to processing mode.

In transitions b and c, the Bimat-cut memory is automatically cleared because RTC-16 (wind-forward ON) is used to initiate these transitions. To provide the same protection for transition a, it is recommended that the processor be inhibited via RTC-5 (read-out drive ON) before a photographic sequence occurs, and then be released via RTC-16 after the sequence is complete. When RTC-16 releases the inhibit on processing, it also clears the Bimat-cut memory erasing any inadvertent command before Bimat cut is executed.

## 2.4 PHOTOGRAPHIC SUBSYSTEM POWER CONSUMPTION

### 2.4.1 Summary

The rate of power consumption of the PS is dependent upon three conditions: (1) the rate of heat radiation and conduction into and out of the subsystem, (2) the operating mode of the subsystem, and (3) the prime voltage level supplied to the PS from the spacecraft. The information supplied in this section provides a brief summary of the maximum power consumption of the PS that can be expected when these conditions are normal.

### 2.4.2 Discussion of Power Consumption Data

The energy-dissipation rates presented in the accompanying tables and figures are based on a prime voltage-supply level of 30.5 v dc with the exception of the values presented for the solar-eclipse mode. Maximum power consumption of the subsystem during each of its six major operating modes is presented in Table 2-8. Table 2-9 presents the maximum consumption for the various components of the subsystem. Typical power profiles for each mode are presented in Figure 2-35 through Figure 2-39.

Heater dissipation rates were obtained from a worst-case cold-orbit computed analysis of the thermal model (TM). The power consumptions during the solar-eclipse, standby, and processing modes are primarily due to heater dissipation. Because the heater cycling rates decrease as the requirements for heat are lessened, the power consumption during these modes decreases with time until thermal equilibrium is achieved.

The effects of this are shown in Figure 2-35 and 2-36. In addition, because the heaters are inhibited in the photographic and read-out modes, the average (not maximum as given below) consumption in these modes is generally less than in the associated standby mode.

Some of the PS components draw comparatively large transient currents when initially energized; however, the duration of these transients is such that the total energy dissipated is negligible. Total energy consumption for the various operating modes is not presented because it is dependent on ground originated commands.

TABLE 2-8

MAXIMUM POWER CONSUMPTION OF THE PS DURING THE SIX MAJOR OPERATING MODES

| Operating Mode | Power (watts) |
|---|---|
| Solar eclipse | 22.1 |
| Standby | 77.2 |
| Photographic | 104.9 |
| Processing | 109.4 |
| Bimat cut | 86.6 |
| Read-out | 61.4 |

TABLE 2-9

MAXIMUM POWER CONSUMPTION OF EACH ELECTRICAL COMPONENT IN THE PS

| Components | Power (watts) |
|---|---|
| 80-mm shutter motor | 6.7 |
| 24-inch shutter motor and solenoid | 24.3 |
| 80-mm exposure adjust motor | 18.8 |
| 24-inch exposure adjust motor | 9.0 |
| Film advance motor and brake | 19.9 |
| V/H sensor and electronics | 12.5 |
| Film-clamp and vacuum-draw motor | 25.0 |
| Data electronics and pinlights | 0.84 |
| Supply-spool brake | 6.7 |
| Supply-spool motor | 3.3 |
| Take-up motor and brake | 8.8 |
| Read-out take-up motor and brake | 6.7 |
| Supply-spool clutch | 6.5 |
| Read-out scanner clutch | 3.7 |
| Bimat drive motor | 3.1 |
| Bimat cutter | 0.24 |
| Instrumentation | 0.24 |
| CCP control logic | 1.93 |
| Reference frequency generator | 0.14 |
| Sweep and sync logic | 0.05 |
| Photomultiplier tube and supply | 2.0 |
| Reference voltage generator | 0.46 |
| Video amplifier | 0.9 |
| Sweep, sync and LST power | 18.9 |
| Filament | 3.2 |
| High-voltage supply and beam current | 9.0 |
| Drum anode motor | 10.3 |

TABLE 2-9 (Continued)

| Components | Power (watts) |
|---|---|
| Read-out scanner motor | 3.5 |
| Continous prime supply losses | 0.5 |
| DC/DC converter losses | 9.64 |
| Camera shroud and film-cassette heater | 7.0 |
| 24-inch lens heater | 2.75 |
| 24-inch and 80-mm window heater | 4.1 |
| Upper pressure-shell heater | 8.31 |
| Lower pressure-shell heater | 7.77 |
| Fin base area No. 1 heater* | 4.81 watts |
| Fin base area No. 2 heater | 18.2 |
| Fin base area No. 3 heater | 18.0 watts |
| Processor heater | 9.09 |
| Dryer | 16.7 |
| Each heater controller (10 controllers) | 0.065 |

* The energy dissipation of fin base area No. 1 heater was trimmed to maintain a total average heater dissipation of 15 watts at 25 volts for operation in the solar eclipse mode.

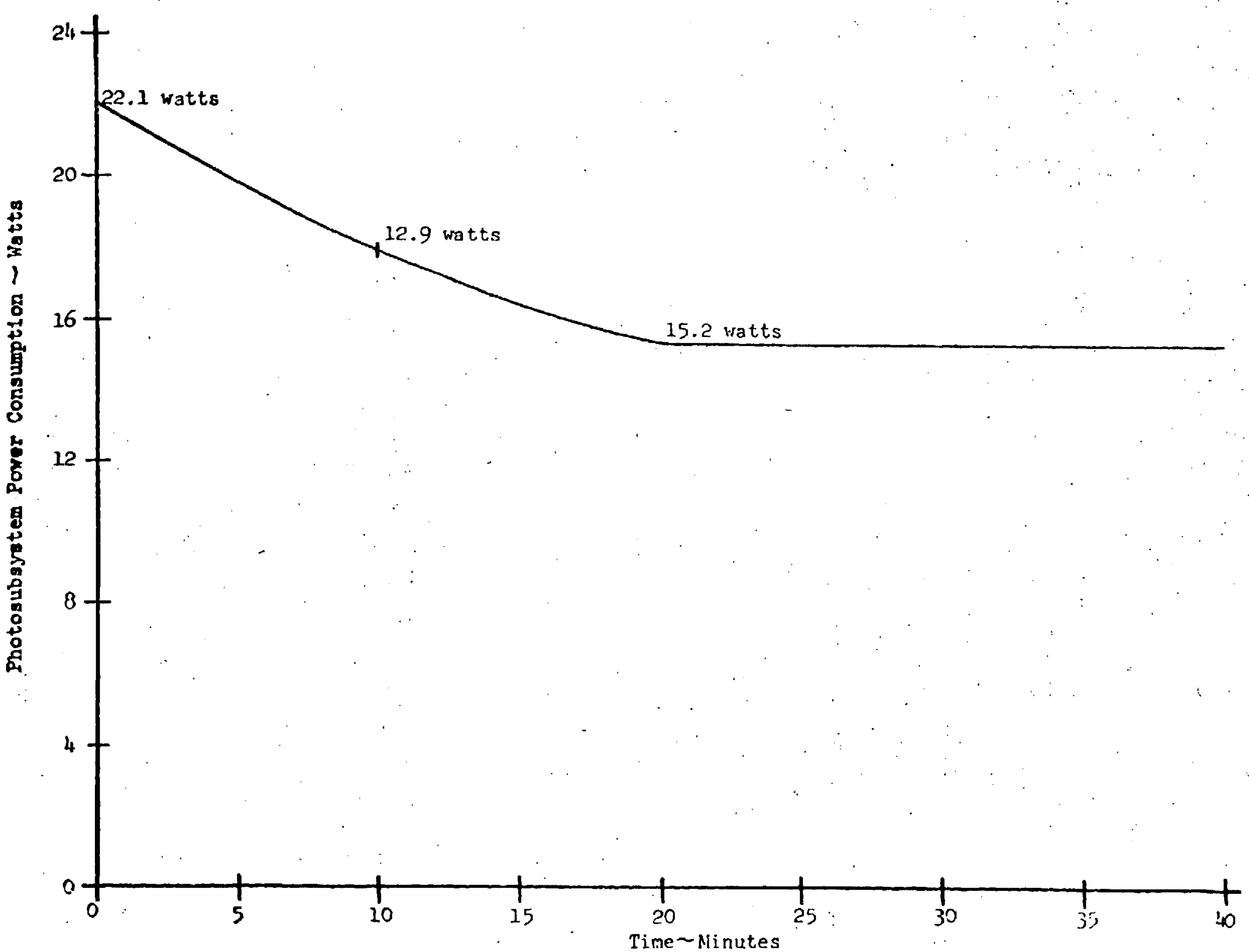



Figure 2-35. Typical Solar Eclipse Profile

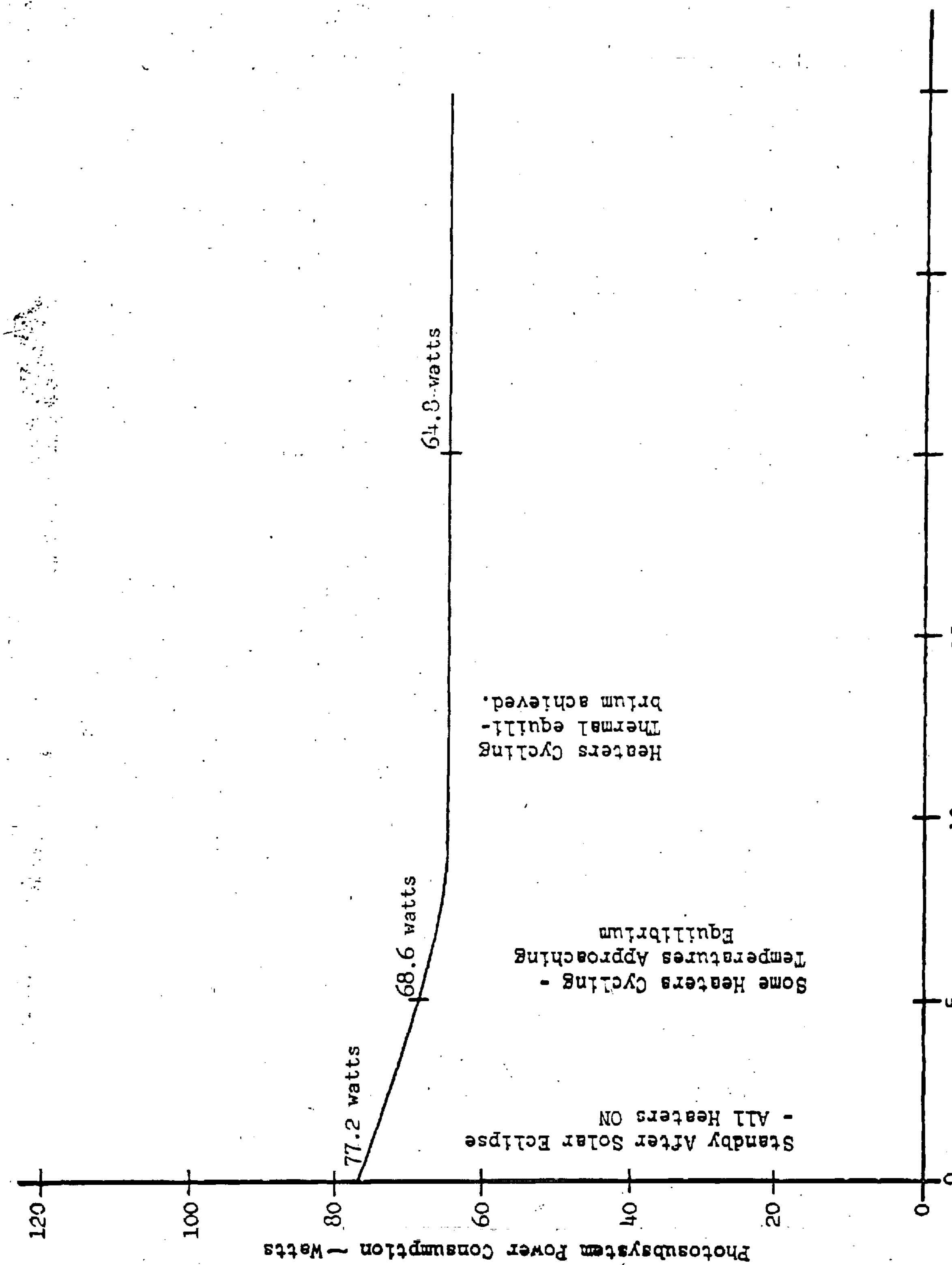



Figure 2-36. Typical Standby Mode Power Profile

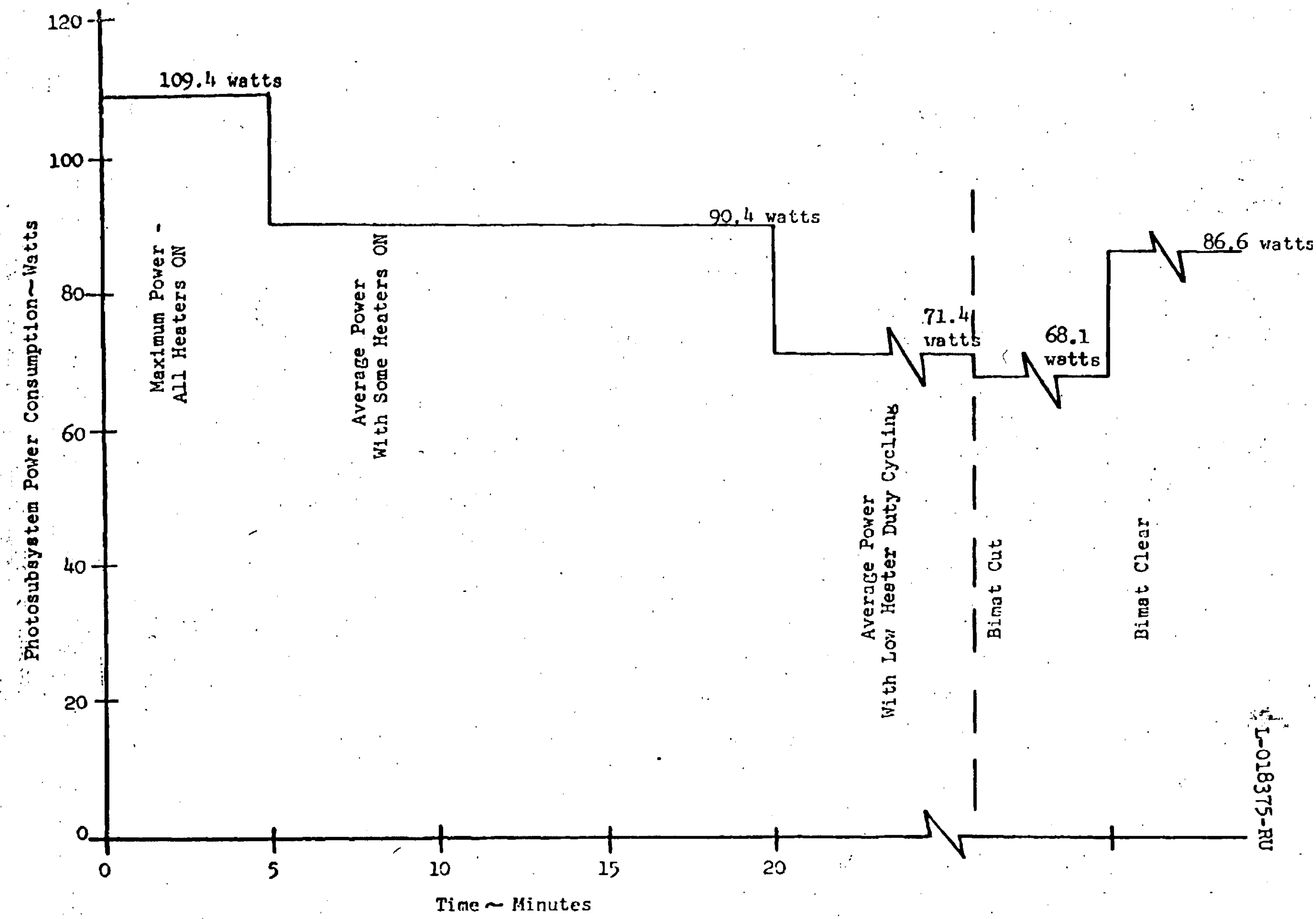



Figure 2-37. Typical Processing and Bimat Cut Mode Power Profiles

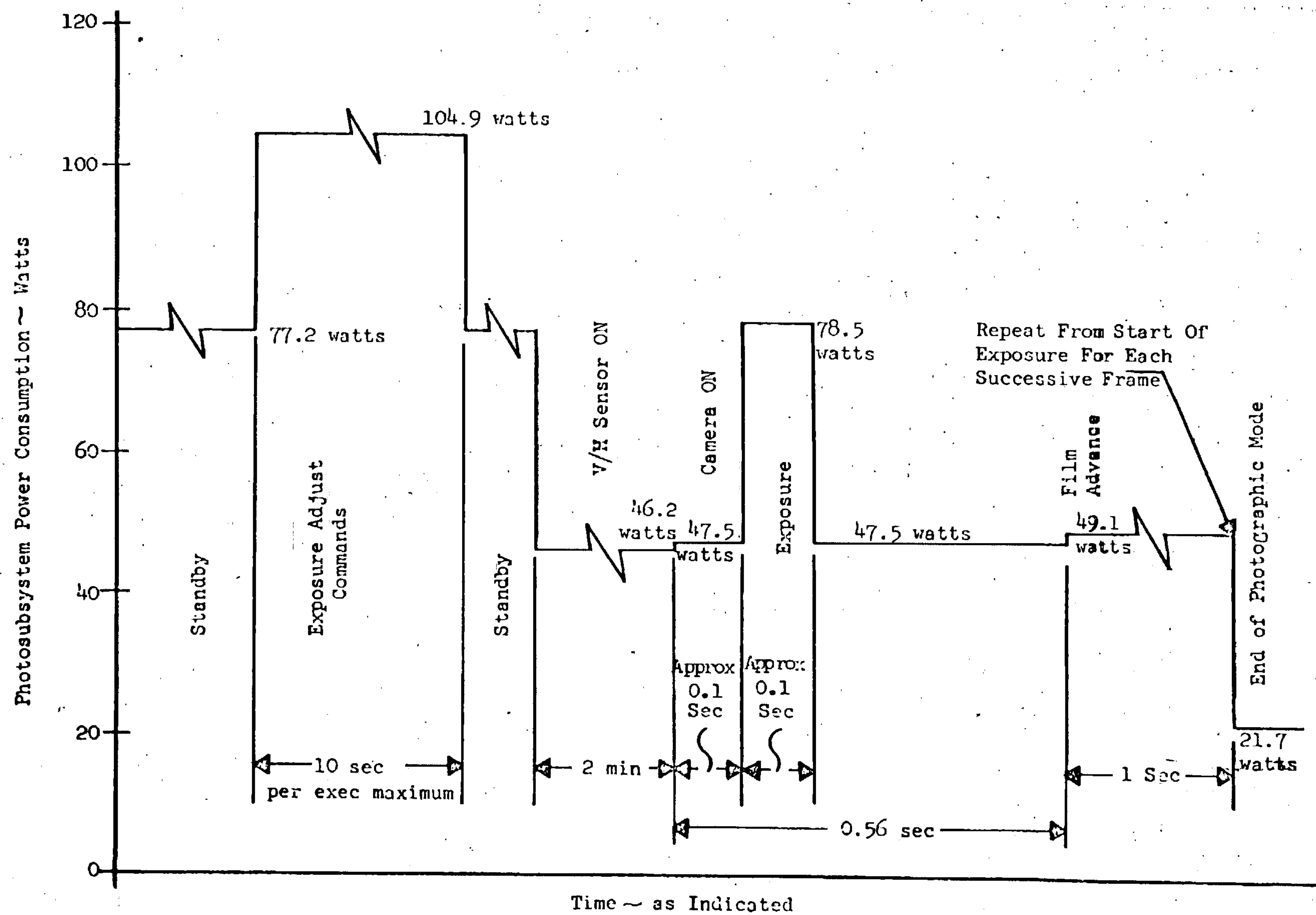



Figure 2-38. Typical Photographic Mode Power Profile

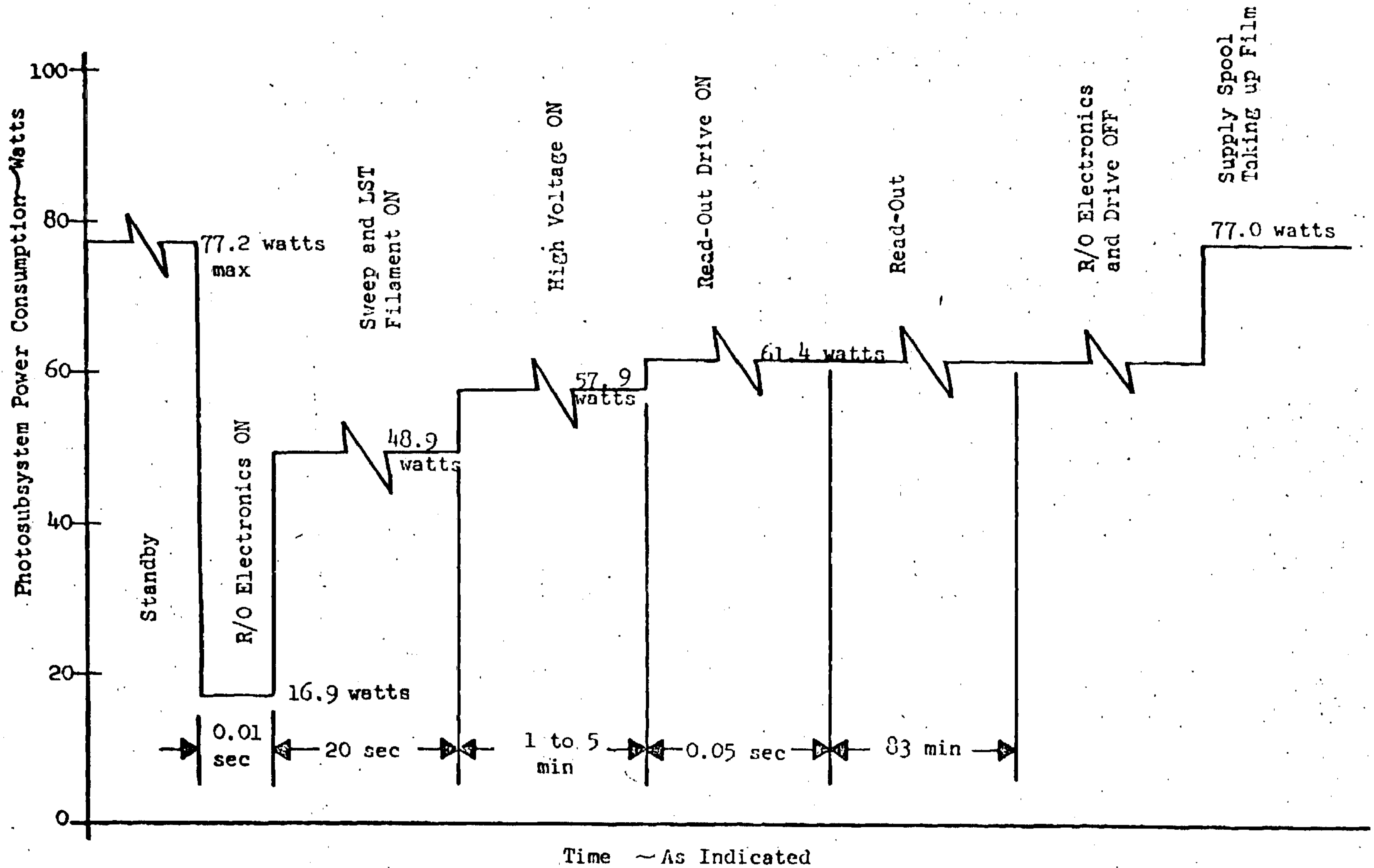



Figure 2-39. Typical Read-Out Mode Power Profile

## 2.5 LOGIC RELATIONSHIPS FOR THE COMMAND CONTROL AND PROGRAMMING (CCP) UNIT

### 2.5.1 General

The logic relationships in this section are keyed to sheets of the CCP logic diagram (these sheets are included at the end of paragraph 2.5). Identification of the input, internal, and output signals for the CCP is contained in the following tables:

| | |
|---|---|
| Table 2-10 | External Commands to CCP |
| Table 2-11 | Signals from Photo Subsystem |
| Table 2-12 | CCP Internal Signals |
| Table 2-13 | CCP Signals to Photo Subsystem |
| Table 2-14 | Telemetry and Hard Line Points |

In these tables (except for telemetry points indicated to be changing state) the signal label corresponds to the more positive (HIGH, TRUE, or ONE) level of the function states. For example, input FSS is TRUE when focus stop position exists; but input $\overline{\text{SPS}}$ is FALSE when spot-stop position exists and TRUE when it does not exist. This convention is followed throughout the equations and descriptions following the tables.

The inputs to each flip-flop memory are shown for the set condition of the memory, with set inputs given to the left of * and clear inputs to the right. The states shown for the clear inputs are necessary conditions for set action. The inverse state on any clear input will give a clear condition. Figure 2-40 is a drawing of the CCP Camera signals.

TABLE 2-10

EXTERNAL COMMANDS TO CCP

| Logic Diagram Sheet | Command | Description | Verification** |
|---|---|---|---|
| 7 | SPC-1 | V/H sensor ON | CTL-8 |
| 7 | SPC-2 | Camera ON | CTL-9 |
| 8 | SPC-3 | Read-out anode & electronics ON | RTL-28 |
| 4 | SPC-4 | V/H sensor OFF | CTL-8 |
| 8 | RTC-5 | Read-out scanner drive ON | RTL-29 |
| 5 | RTC-6 | Read-out scanner drive OFF | RTL-29 |
| CVI-1* | RTC-7 | Camera Shutter advance one step | CTL-15,(CTL-11) |
| 5 | RTC-8 | Cut Bimat | PTL-22 |
| 8 | RTC-9 | Inhibit all heater power | (ETL-40) |
| CVI-2* | RTC-11 | LST focus increase one step | RTL-31 |
| CVI-3* | RTC-12 | LST focus decrease one step | RTL-31 |
| CVI-4* | RTC-13 | Photovideo gain increase one step | RTL-31 |
| CVI-5* | RTC-14 | Photovideo gain decrease one step | RTL-31 |
| 5 | RTC-16 | Wind forward ON (Processor ON) | RTL-28 |
| 4 | SPC-18 | Solar eclipse ON | CTL-16 |
| 4 | SPC-19 | Solar eclipse OFF | CTL-16 |
| 7 | SPC-26 | Camera rate fast | CTL-15,(CTL-10a) |
| 7 | SPC-27 | Camera rate slow | CTL-15,($\overline{\text{CTL-10a}}$) |
| 4 | SPC-28 | Camera sequence | ($\overline{\text{CTL-10b}}$) |
| 4 | SPC-29 | Camera sequence | (CTL-10b) |
| 4 | SPC-30 | Camera sequence | ($\overline{\text{CTL-10c}}$) |
| 4 | SPC-31 | Camera Sequence | (CTL-10c) |
| 2 | HLC-2 | Ground focus test | |

* Sheet 6 - CVI means Command Verification Instrumentation. The commands are not executed in the CCP logic. However, the CVI signals are used in the CCP for command verification telemetry inputs.

** NOTE: Verifications that are <u>not</u> in parentheses are signaled by changes of state. See sheet 6 of the logic diagram.

TABLE 2- 11

SIGNALS FROM PHOTO SUBSYSTEM

| Logic Diagram Sheet | Signal | Description |
|---|---|---|
| 2 | SLF | Supply looper full |
| 2 | SLE | Supply looper empty |
| 4 | CLF | Camera looper full |
| 2,5 | CLE | Camera looper empty |
| 2,5 | RLF | Read-out looper full |
| 8 | RLP | Read-out looper partial (near empty) |
| 2,5 | RLE | Read-out looper empty |
| 2 | TLF | Take-up looper full |
| 2 | TLE | Take-up looper empty |
| 5 | BCI | Bimat cut power inhibit |
| 5 | BCO | Bimat cut power OFF |
| 2,5 | BMC | Bimat cut and clear |
| 4 | EOS | End of sequence (end of film advance) |
| 8 | FSS | Focus stop position |
| 7 | IMC | Initiate film clamp and draw vacuum |
| 7 | SHL | 80-mm shutter limit |
| 3 | SLT | 24-inch shutter action |
| 3 | SST | Platen motion (shutter start input) |
| 5 | SPS | Spot stop position |
| 1 | SRF | Secondary reference frequency |

TABLE 2-12

CCP INTERNAL SIGNALS

| Logic Diagram Sheet | Signal | Description |
|---|---|---|
| 7 | PPS | Preset pulse signal (power ON clear) |
| 5 | BME | Bimat motor enable |
| 5 | CBC | Cut-Bimat command memory ON |
| 4 | TS-2 | Solar eclipse memory ON |
| 4 | TS-3 | Camera enable |
| 4 | TS-4 | Camera memory ON |
| 5 | TS-5 | Wind forward memory ON (after BMC only) |
| 5 | TS-6 | Read-out enable |
| 8 | TS-7 | Read-out drive motor ON |
| 8 | TS-8 | Take-up forward enable (ignored after BMC) |

Equations for the above signals are given in paragraph 2.5.2.1.

TABLE 2-13

CCP SIGNALS TO PHOTO SUBSYSTEM

| Logic Diagram Sheet | Signal | Description |
|---|---|---|
| 1 | ORF-1,2 | 400 cps |
| 7 | MS-1,2 | 24-inch shutter motor (TS-4 & 400 cps) |
| 5 | MS-5,6 | Read-out drive motor (TS-7 & 400 cps) |
| 5 | MS-9,10,11,12 | Drum anode motor (TS-6 & 50 cps, 2 phase) |
| 5 | MS-13,14 | Bimat motor (BME & 400 cps) |
| 2 | CAS-1* | Camera motor forward memory ON |
| 2 | CAS-7 | Camera motor reverse |
| 2 | CAS-5 | Camera motor ON |
| 2 | CAS-12 | Supply brake disengaged |
| 2 | CAS-13 | Supply motor ON (reverse only) |
| 2 | CAS-14 | Take-up motor forward |
| 2 | CAS-15 | Take-up motor reverse |
| 2 | CAS-16 | Take-up motor ON |
| 4 | CAS-17 | ±20V & +6.3V converters ON |
| 4 | CAS-18 | Day heater inhibit |
| 4 | CAS-19 | Night heater inhibit |
| 5 | CAS-20 | Read-out high-voltage ON |
| 5 | CAS-21 | Processor/dryer heater OFF |
| 5 | CAS-6 | Bimat cut power ON |
| 7 | CAS-2 | Film clamp and draw vacuum ON |
| 7 | CAS-3 | 80-mm shutter memory ON |
| 7 | CAS-8 | 24-inch shutter action |

* Equations for signal CAS-1 and all signals listed below it are given in paragraph 2.5.2.2. For TCI, see CAS-8.

TABLE 2-13 (Continued)

| Logic Diagram Sheet | Signal | Description |
|---|---|---|
| 7 | CAS-4 | V/H memory ON (read-out relay in V/H state) |
| 5 | CAS-10 | Read-out relay in read-out state |
| 5 | CAS-11 | Read-out clutch disengaged (readout forward release) |
| 7 | TCI | Time code interrogation |

TABLE 2-14

TELEMETRY & HARD-LINE POINTS
(all TPL and HTL are hard-line points)

| Logic Diagram Sheet | EKC Point Designation | Boeing Point Designation | Indication | |
|---|---|---|---|---|
| 1 | TPL-7 | | (SRF) Secondary reference frequency | |
| 4 | TPL-8 | | (TS-2) Solar eclipse memory ON | |
| 5 | TPL-9 | | (TS-5) Wind forward memory ON (after BMC only) | |
| 4 | TPL-10 | | (TS-4) Camera Memory ON | |
| 3 | CTL-7 | PB05 | (5 bits) } 24-inch platen motions | |
| 3 | HTL-2 | | (LSB only) } (SST count) | |
| 3 | CTL-6 | PB04 | (5 bits) } 24-inch shutter actions | |
| 3 | HTL-1 | | (LSB only) } (SLT count) | |
| 7 | CTL-10a | | Camera rate memory fast | SPC-26 · $\overline{\text{SPC-27}}$ |
| 4 | CTL-10b | PC03 | Camera sequence memory | SPC-29 · $\overline{\text{SPC-28}}$ |
| 4 | CTL-10c | | Camera sequence memory | SPC-31 · $\overline{\text{SPC-30}}$ |
| 5 | PTL-18 | PC07 | Bimat not cut & clear (state low if cut and clear) | |
| | PTL-19 | PC08 | Bimat take-up (changing state) | |
| 8 | ETL-40 | PC20 | (RTC-9) Inhibit all heater power (inhibit state low) | |
| | CTL-11 | PC04 | Camera exposure setting | |
| | | PC18 | Camera thermal door open | |
| 6 | | Command Verifications by Changing State | | |
| | CTL-8 | PC01 | V/H sensor ON, OFF | SPC-1,4 |
| | CTL-9 | PC02 | Camera ON | SPC-2 |
| | CTL-15 | PC15 | Camera exposure or frame rate | RTC-7, SPC-26,27 |

TABLE 2-14 (Continued)

| Logic Diagram Sheet | EKC Point Designation | Boeing Point Designation | Indication | |
|---|---|---|---|---|
| 6 | CTL-16 | PC16 | Solar eclipse ON, OFF | SPC-18,19 |
| | PTL-22 | PC09 | Cut Bimat | RTC-8 |
| | RTL-28 | PC10 | Read-out electronics ON or wind forward | SPC-3, RTC-16 |
| | RTL-29 | PC11 | Read-out drive ON, OFF | RTC-5,6 |
| | RTL-31 | PC12 | LST focus or photovideo gain | RTC-11,12,13,14 |

NOTES:

1. FIRST TWO & LAST OF x NO OF CYCLES ARE SHOWN EXCEPT FOR CASE OF x=1 WHEN ONLY THE FIRST CYCLE SHOWN APPLIES. IF SPC-28 OCCURS AFTER SPC-29 & SPC-30 AFTER SPC-31, x=1. IF SPC-29 OCCURS AFTER SPC-28 & SPC-30 AFTER SPC-31, x=4. IF SPC-28 OCCURS AFTER SPC-29 & SPC-31 AFTER SPC-30, x=8. IF SPC-29 OCCURS AFTER SPC-28 & SPC-31 AFTER SPC-30 x=16.
2. MOTOR SIGNALS MS-1, MS-2, ARE DEFINED BY DWG 1204-102
3. W=RATE OF IMC SHAFT ROTATION WHERE 0.097 < W < 0.600RPS
4. CAS-4 SHALL GO FROM LOGIC 1 TO LOGIC 0 WHEN CAS-8 GOES FROM LOGIC 1 TO LOGIC 0 & x=4, 8, OR 16. WHEN x=1 CAS-4 SHALL REMAIN AT LOGIC 1 UNTIL SPC-4 IS RECD
5. FAST FRAME RATE OCCURS WHEN SPC-26 OCCURS AFTER SPC-27. SLOW OCCURS WHEN SPC-27 OCCURS AFTER SPC-26
6. SIGNAL DESIGNATIONS ARE AS LISTED IN EASTMAN KODAK COMPANY SPECIFICATION 1225-134
7. THE EOS SWITCH MAY COME TO REST BETWEEN CYCLES IN EITHER THE OPEN OR CLOSED POSITION. THE DURATION OF THE OPEN SWITCH POSITION WILL BE AT LEAST 5 MILLISECONDS.

TABLE I

| V/H ON-OFF (CAS-4) | FRAME RATE NOTE 5 | T' SEC. |
|---|---|---|
| ON | FAST | NOTE 3 |
| ON | SLOW | |
| OFF | FAST | 2.3 ± .7 |
| OFF | SLOW | 9.2 ± 2.8 |

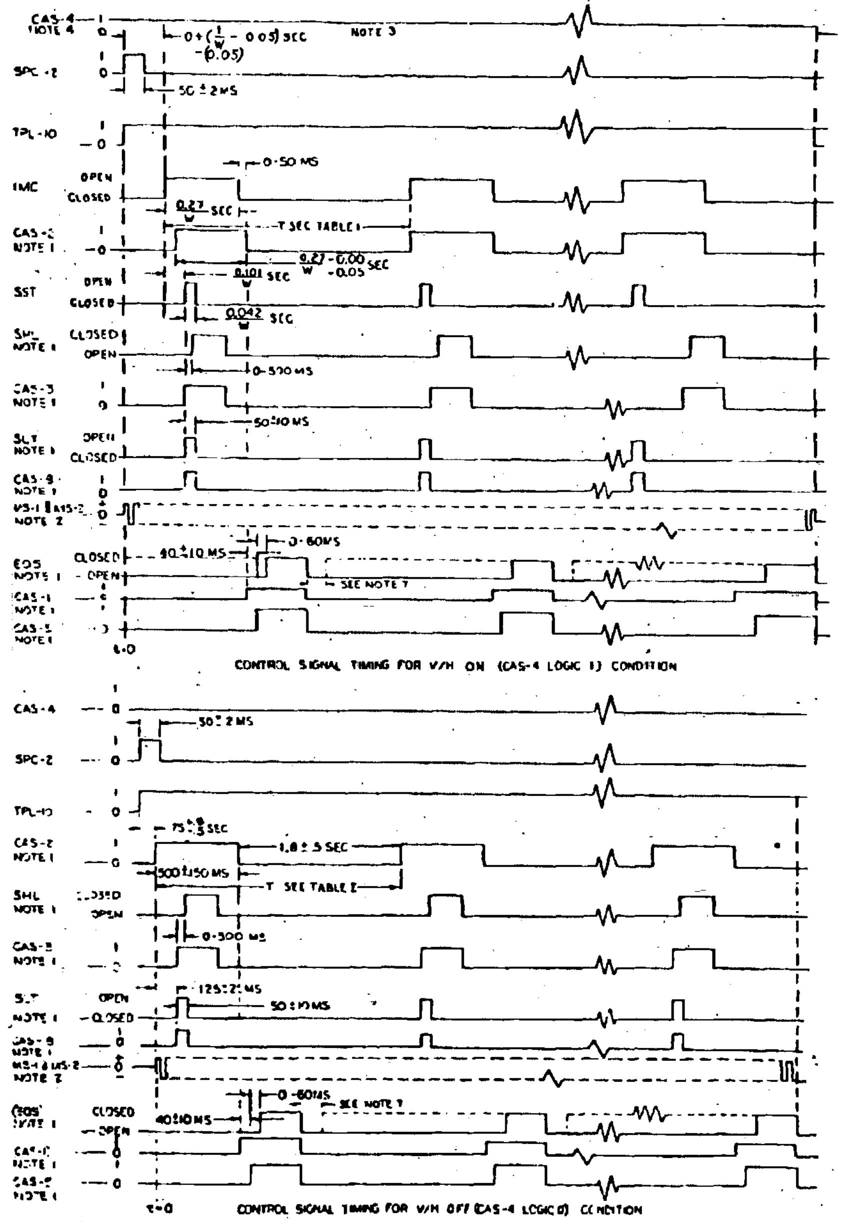



Figure 2-40. CCP Camera Signals

## 2.5.2 Logic Equations

### 2.5.2.1 CCP Internal Signals

#### 2.5.2.1.1 Preset Pulse Signal (PPS) (Sheet 7)

The preset pulse signal (PPS) is generated only at the time of photo subsystem power turn-on prior to launch. Because CCP power is maintained throughout the life of the payload mission, signal PPS occurs only once. It initializes the command control and programming logic states as follows:

| | | |
|---|---|---|
| a. | Solar eclipse memory ON | TS-2 |
| b. | Camera enable state OFF | $\overline{\text{TS-3}}$ |
| c. | Camera memory OFF | $\overline{\text{TS-4}}$ |
| d. | Wind forward memory OFF | $\overline{\text{TS-5}}$ |
| e. | Read-out enable state OFF | $\overline{\text{TS-6}}$ |
| f. | Read-out drive memory OFF | $\overline{\text{TS-7}}$ |
| g. | Take-up forward enable state OFF (due to $\overline{\text{BME}}$) | $\overline{\text{TS-8}}$ |
| h. | Read-out release memory ON, but signal BME is inhibited by TS-2 | $\overline{\text{BME}}$ |
| i. | Cut-Bimat command memory OFF | $\overline{\text{CBC}}$ |
| j. | V/H memory OFF (by collector priming) | $\overline{\text{CAS-4}}$ |
| k. | Bimat-cut power memory OFF | $\overline{\text{CAS-6}}$ |
| l. | Night heater inhibit ON | CAS-19 |

The camera motor reverse is held OFF ($\overline{\text{CAS-7}}$) permanently prior to Bimat cut and clear. The day heater inhibit signal is not present ($\overline{\text{CAS-18}}$) unless Command RTC-9 is given. The camera rate (CTL-10a) and sequence (CTL-10b,c) memories will be in unknown states. All other signals are inhibited by the solar eclipse ON state (see TS-2). Given these initial conditions, command SPC-19 will be needed to turn the solar eclipse memory OFF ($\overline{\text{TS-2}}$), which

will allow turn-on of states BME, TS-8, CAS-11, CAS-14, and CAS-16. This will result in emptying the read-out and camera loopers, a necessary condition for launch, after which the solar eclipse ON state (TS-2) can be reinstated by giving command SPC-18.

2.5.2.1.2 <u>Bimat Motor Enable (BME) (Sheet 5)</u>

$$\text{BME} = \left\lfloor \left(\text{RLF} \cdot \overline{\text{TS-6}} \cdot \overline{\text{BMC} \cdot \text{BCO}} + \text{PPS} + \text{RTC-16}\right) * \overline{\text{RTC-5}} \right\rfloor \cdot \overline{\text{CLE}} \cdot \overline{\text{TS-2}} \cdot \overline{\text{TS-4}} \cdot \overline{\text{TS-6}} \cdot \overline{\text{BMC} \cdot \text{BCO}} \cdot \overline{\text{CAS-4}}$$

This signal is available before Bimat clear only. If the read-out release memory is turned ON the Bimat motor enable signal (BME) exists provided the:

| | | |
|---|---|---|
| a. | Camera looper is not empty | $\overline{\text{CLE}}$ |
| b. | Solar eclipse memory is not ON | $\overline{\text{TS-2}}$ |
| c. | Camera memory is not ON | $\overline{\text{TS-4}}$ |
| d. | Readout enable signal is not ON | $\overline{\text{TS-6}}$ |
| e. | Bimat is not cut and clear | $\overline{\text{BMC} \cdot \text{BCO}}$ |
| f. | V/H memory is not ON | $\overline{\text{CAS-4}}$ |

The read-out release memory can be turned ON by any of the following:

| | | |
|---|---|---|
| a. | Wind forward command | RTC-16 |
| b. | Preset pulse signal (However, the BME signal is inhibited in this case since PPS also turns solar eclipse memory ON.) | PPS |
| c. | Read-out looper full signal | RLF |

The read-out release memory is cleared by a read-out drive ON command (RTC-5).

The presence of the BME signal establishes:

| | | |
|---|---|---|
| a. | Bimat motor drive signals | MS-13,14 |
| b. | Read-out clutch disengaged | CAS-11 |
| c. | Enables Bimat-cut power ON | CAS-6 |
| d. | Enables processor/dryer heater | $\overline{\text{CAS-21}}$ |

2.5.2.1.3 Cut-Bimat Command Memory ON (CBC) (Sheet 5)

$$\text{CBC} = \lfloor \text{RTC-8} * \overline{\text{RTC-16}} \cdot \overline{\text{BCO}} \cdot \overline{\text{PPS}} \rfloor$$

This signal is inhibited after Bimat cut and clear. The cut-Bimat command memory is turned ON by the cut-Bimat command (RTC-8). It is cleared by any of the following:

| | | |
|---|---|---|
| a. | Wind forward command | RTC-16 |
| b. | Bimat-cut power-off signal | BCO |
| c. | The preset pulse signal | PPS |

The presence of the CBC signal establishes:

a. A condition for setting the Bimat-cut power memory
b. Both day and night heater - inhibits
c. Inhibits processor/dryer heaters

2.5.2.1.4 Solar Eclipse Memory ON (TS-2) (Sheet 4)

$$\text{TS-2} = \lfloor (\text{SPC-18} + \text{PPS}) * \overline{\text{SPC-19}} \rfloor$$

The solar-eclipse memory is turned ON either by the preset pulse signal (PPS) at initial power turn-on or by command SPC-18; it is cleared by Command SPC-19. The set state will establish a night heater inhibit condition (CAS-19) and will clear or inhibit all of the following signals:

| | | |
|---|---|---|
| a. | Bimat motor enable | BME |
| b. | Camera forward memory ON | CAS-1 |
| c. | Film clamp and draw vacuum ON | CAS-2 |
| d. | 80-mm shutter memory ON | CAS-3 |
| e. | V/H memory ON | CAS-4 |
| f. | Camera motor ON | CAS-5 |
| g. | Bimat-cut power ON | CAS-6 |
| h. | 24-inch shutter action | CAS-8 |
| i. | Read-out relay in read-out state | CAS-10 |
| j. | Read-out clutch disengaged | CAS-11 |
| k. | Supply brake disengaged | CAS-12 |
| l. | Supply motor ON | CAS-13 |
| m. | Take-up motor forward (after Bimat clear) | CAS-14 |
| n. | Take-up motor reverse (before Bimat clear) | CAS-15 |
| o. | Take-up motor ON (before and after Bimat clear) | CAS-16 |
| p. | ±20V and +6.3V converters ON | CAS-17 |
| q. | Read-out high-voltage ON | CAS-20 |
| r. | Processor/dryer heater ON | $\overline{\text{CAS-21}}$ |
| t. | Time code interrogation | TCI |

If the read-out circuits happen to be in the focus stop condition at the time solar-eclipse memory turns ON, then signal TS-2 causes the scanner to home on the spot-stop position (SPS) prior to read-out turn-off (see TS-7).

2.5.2.1.5 Camera Enable (TS-3) (Sheet 4)

$$\text{TS-3} = \overline{\text{CLF}} \cdot \overline{\text{TS-2}} \cdot \overline{\text{TS-6}} \cdot \overline{\text{SPC-4}} \cdot \overline{\text{MULTIPLE SEQ COMPL}}$$

The presence of this signal is a condition for setting the following:

a. V/H memory ON CAS-4

b. Camera memory ON TS-4

The termination of this signal will clear the first memory on the negative-going transition and will dc clear the second memory. Camera enable is established provided all of the following states are in effect:

a. Programmed multiple photo sequence has not been completed

b. V/H OFF command is not present $\overline{\text{SPC-4}}$

c. Camera storage looper is not full $\overline{\text{CLF}}$

d. Solar eclipse memory is not ON $\overline{\text{TS-2}}$

e. Read-out enable signal is not ON $\overline{\text{TS-6}}$

2.5.2.1.6 Camera Memory ON (TS-4) (Sheet 4)

$$\text{TS-4} = \lfloor \text{SPC-2} * \text{TS-3} \cdot \overline{\text{SINGLE SEQ COMPL}} \rfloor$$

This memory is set by command SPC-2 provided the camera enable condition (TS-3) is present. It is cleared by any of the following:

a. Completion of programmed photo sequence (single or multiple)

b. Reception of V/H OFF command SPC-4

c. Filling of the camera-storage looper CLF

d. Turn-on of the solar-eclipse memory TS-2

e. Turn-on of the read-out enable signal TS-6

Therefore, the camera mode can be terminated by any of three commands: SPC-4, SPC-18, SPC-3. It can also be terminated by the use of Commands SPC-28, 29, 30, 31 to shorten the programmed sequence.

The presence of this signal inhibits the Bimat motor and all heaters; inhibits setting of the V/H ON and camera rate FAST memories; enables camera sequence signals CAS-1, 2, 3, 5, 8 and TCI; turns ON the wind-forward memory TS-5, after Bimat cut and clear only; and turns ON the motor signals MS-1, 2 for the 24-inch shutter.

2.5.2.1.7 Wind Forward Memory ON (TS-5) (Sheet 5)

$$TS\text{-}5 = \underline{(TS\text{-}4 \cdot BMC \cdot BCO) * \overline{RTC\text{-}8} \cdot \overline{TS\text{-}2} \cdot \overline{PPS} \cdot SPS}$$

This memory is turned on by TS-4 (command SPC-2) after Bimat cut and clear only. It can be cleared by any of the following:

| | | |
|---|---|---|
| a. | Cut-Bimat command | RTC-8 |
| b. | Solar-eclipse memory ON | TS-2 |
| c. | Preset pulse signal | PPS |
| d. | Movement of the read-out scanner away from spot-stop position. | $\overline{SPS}$ |

Therefore, this memory can be turned OFF by any of three command combinations:

| | | |
|---|---|---|
| a. | Cut-Bimat command | RTC-8 |
| b. | Solar eclipse ON command | SPC-18 |
| c. | Read-out electronics ON followed by drive ON command. | SPC-3 & RTC-5 |

Turn-on of this memory inhibits signals CAS-7, 13, 15 and enables signals CAS-11, 12, 14, 16.

2.5.2.1.8 Read-Out Enable (TS-6) (Sheet 5)

$$TS\text{-}6 = \overline{SPS} + \underline{SPC\text{-}3 * (BMC \cdot BCO + \overline{RLF}) \cdot \overline{SPC\text{-}2} \cdot \overline{RTC\text{-}6} \cdot \overline{TS\text{-}2} \cdot \overline{PPS}}$$

This signal exists under either or both of the following conditions:

a. Spot stop switch is open ($\overline{SPS}$)

b. Read-out electronics memory is ON.

The memory is turned ON by command SPC-3 provided all of the following conditions are in effect:

| | | |
|---|---|---|
| a. | Read-out looper is not full (before Bimat clear only) | $\overline{RLF}$ |
| b. | Camera ON command is not present | $\overline{SPC\text{-}2}$ |
| c. | Read-out drive OFF command is not present | $\overline{RTC\text{-}6}$ |
| d. | Solar-eclipse memory is not ON | $\overline{TS\text{-}2}$ |
| e. | Preset pulse signal is not present | $\overline{PPS}$ |

After turn-on of this memory, it will be cleared by the inverse of any of the five conditions listed above. Therefore, it can be cleared by any of the three commands: SPC-2, RTC-6, SPC-18.

Prior to Bimat clear the presence of this signal inhibits the Bimat motor, all heaters, all camera operations, and signals CAS-11, 14; it turns on signals CAS-10, 17, 20 and MS-9, 10, 11, 12 (drum anode motor); it enables signals CAS-15, 16 and turn-on of the read-out drive motor condition (see TS-7).

After Bimat clear the effect of this signal is the same except that:

a. The Bimat motor and processor/dryer heater are permanently disabled

b. Control of signals CAS-11, 14, 15, 16 is with the wind-forward memory (see TS-5).

2.5.2.1.9 <u>Read-out Drive Motor ON (TS-7) (Sheet 8)</u>

$$\text{TS-7} = \lfloor \text{RTC-5} * \text{TS-6} \rfloor \cdot \lfloor (\text{RTC-5} + \text{TS-2}) * \overline{\text{FSS} \cdot \lfloor \text{SPC-3} * \overline{\text{FSS}} \rfloor} \rfloor$$

The presence of state TS-7 results in turn-on of motor signals MS-5, 6 for the read-out drive unit.

The read-out drive motor is turned ON by command RTC-5 if the read-out enable state (TS-6) has first been obtained by setting the read-out electronics memory with command SPC-3. This occurs because RTC-5 sets both the first and second memories indicated above in the expression for TS-7. Since the third memory in the expression has already been set by SPC-3, the motor is turned OFF when the read-out scanner reaches focus-stop position because input FSS clears the second and third memories. Upon reception of a second RTC-5 command the second memory is set, the motor turns back ON, and scanning resumes. If the read-out electronics memory has been cleared (by commands SPC-2 or RTC-6, for example) scanning terminates when the spot-stop position (SPS) at the edge of the film near the edge data is reached. If the read-out electronics memory is still ON, maintaining the TS-6 condition, the scanner continues to cycle back and forth unless the focus-stop action (FSS) is again enabled by giving another SPC-3 command to set the third memory. This and each additional SPC-3 must be followed by one RTC-5 to resume normal scanning. Note that only the first SPC-3 must be followed by two RTC-5 commands to establish scanner cycling. The negation of condition TS-6 will terminate scanning at the spot-stop position (SPS), after which one SPC-3 and two RTC-5 commands will again be required to obtain the read-out mode. Also, note that if the circuit happens to be in a focus-stop state (second and third memories cleared) when solar eclipse occurs, then input TS-2 will set the second memory; this ensures that the read-out drive will cycle the scanner home to the spot-stop position, permitting the read-out circuits to turn OFF.

2.5.2.1.10 Take-Up Forward Enable (TS-8) (Sheet 8)

This signal is ignored after Bimat clear; therefore condition TS-5, which occurs only after Bimat clear, can be omitted from the following expressions. If the read-out looper is not near empty ($\overline{RLP}$) and the read-out clutch is disengaged (CAS-11 = BME), then the memory is in the set state such that the take-up forward-enable-signal tracks the Bimat motor enable: TS-8 = BME. If the read-out looper does go near empty (RLP), and either:

a. the looper empties (RLE), or
b. the read-out clutch engages ($\overline{\text{CAS-11}} = \overline{\text{BME}}$)

then the memory state is such that signal TS-8 is absent until all of the following conditions are established to set the memory:

| | |
|---|---|
| a. The Bimat motor enable signal returns (read-out clutch disengages) | BME |
| b. The read-out looper empty switch closes | $\overline{RLE}$ |
| c. The read-out looper partial switch closes | $\overline{RLP}$ |

$$\text{TS-8} = \llcorner \overline{RLP} * BME \cdot \overline{RLE} \lrcorner$$

With the setting of this memory, the condition reverts to TS-8 = BME until the memory is again cleared.

2.5.2.2 CCP Signals to the PS

2.5.2.2.1 Camera-Motor-Forward Memory ON (CAS-1) (Sheet 2)

$$\text{CAS-1} = \llcorner \text{CAS-2 INT} * \overline{EOS} \cdot \overline{\text{CAS-7}} \cdot \overline{PPS} \cdot \overline{\text{HLC-2}} \lrcorner$$

This memory is set by a film-clamp and draw-vacuum signal (CAS-2 INT) delayed sufficiently to allow sequencing of the shutters, at a rate subject to a condition stored in the camera-rate memory (see CTL-10a). It is cleared by any of the following:

a. End of sequence signal (end of film advance) EOS
b. Camera-motor reverse state (after Bimat clear) CAS-7
c. Preset pulse signal PPS
d. Ground-focus test command HLC-2

The set condition of this memory enables the camera-motor ON signal (CAS-5).

2.5.2.2.2 Film-Clamp and Draw-Vacuum ON, Internal (CAS-2 INT) (Sheet 7)

$$\text{CAS-2 INT} = \text{TS-4} \cdot (\text{CAS-4} \cdot \text{IMC} + \overline{\text{CAS-4}} \cdot \text{INT Clock})$$

This signal is enabled by a camera-memory ON state (TS-4) subject to a condition stored in the camera-rate memory (see CTL-10a). It is initiated by the image motion compensation signal (IMC) in the V/H mode (CAS-4) or by the internal clock when not in the V/H mode ($\overline{\text{CAS-4}}$). In turn, it serves as a trigger for TCI, CAS-3, CAS-8, CAS-1, and CAS-5.

Film Clamp and Draw-Vacuum ON (CAS-2) (Sheet 7)

$$\text{CAS-2} = \text{IMC} + \text{CAS-2 INT}$$

This is the actual film-clamp and draw-vacuum signal into the camera. Its rate is fast or slow as a function of CTL-10a when triggered by the internal clock, but is fast, only, when it is a function of the V/H sensor.

2.5.2.2.3 80-mm Shutter Memory ON (CAS-3) (Sheet 7)

$$\text{CAS-3} = \lfloor \text{TCI} * \overline{\text{PPS}} \cdot \overline{\text{SHL}} \rfloor$$

This memory is set by the time-code interrogation signal (TCI) at a rate subject to a condition stored in the camera rate memory (see CTL-10a). It is cleared by either (1) the 80-mm shutter-limit signal (SHL) or (2) the preset pulse signal (PPS).

2.5.2.2.4 V/H Memory ON (Read-out Relay in V/H State) (CAS-4) (Sheet 7)

$$CAS\text{-}4 = \lfloor (SPC\text{-}1 \cdot TS\text{-}3 \cdot \overline{TS\text{-}4}) * TS\text{-}3AC \rfloor$$

This memory is set by V/H ON command SPC-1 provided:

| | | |
|---|---|---|
| a. | Camera enable has been established | TS-3 |
| b. | Camera memory has not been set by SPC-2 | $\overline{TS\text{-}4}$ |

This memory is cleared by the negative-going transition when condition TS-3 is terminated. This is accomplished by any of the following:

| | | |
|---|---|---|
| a. | Completion of a multiple photo sequence | |
| b. | Reception of V/H OFF command | SPC-4 |
| c. | Filling of the camera-storage looper | CLF |
| d. | Turn-on of the solar-eclipse memory | TS-2 |
| e. | Turn-on of the read-out enable signal | TS-6 |

The presence of this signal turns ON the ±20V and +6.3V Converters signal (CAS-17).

2.5.2.2.5 Camera Motor ON (CAS-5) (Sheet 2)

$$CAS\text{-}5 = \overline{TS\text{-}2} \cdot (CAS\text{-}1 + CAS\text{-}7)$$

This signal is generated by either (1) Camera-motor-forward memory ON (CAS-1) or (2) Camera motor reverse signal (CAS-7), provided the solar eclipse memory is OFF ($\overline{TS\text{-}2}$).

Onset of the signal is delayed by a single-shot circuit. Prior to Bimat clear CAS-1 is the only activating signal.

2.5.2.2.6 Bimat-Cut Power ON (CAS-6) (Sheet 5)

$$CAS\text{-}6 = BME \cdot \underline{(CBC \cdot \overline{BCI}) * \overline{RTC\text{-}16} \cdot \overline{BCO} \cdot \overline{PPS}}$$

This signal is available prior to Bimat clear in the presence of the Bimat motor enable condition (see BME) provided the Bimat-cut power memory has been set. Setting of this memory is contingent upon both of the following:

a. The cut-Bimat command memory is ON — CBC
b. The cutter roller is in proper position — $\overline{BCI}$

This memory is cleared by any of the following:

a. Wind forward command — RTC-16
b. Bimat-cut power off switch — BCO
c. The preset pulse signal — PPS

2.5.2.2.7 Camera-Motor Reverse (CAS-7) (Sheet 2)

$$CAS\text{-}7 = \underline{SLE * \overline{SLF}} \cdot BMC \cdot \overline{TS\text{-}5} \cdot \overline{TS\text{-}6} \cdot (\overline{CLE} + \overline{RLE})$$

The camera-motor reverse signal is available only if all the following conditions are in effect:

a. The Bimat has been cut and is clear — BMC
b. The wind forward memory is not ON — $\overline{TS\text{-}5}$
c. The read-out enable signal is not ON — $\overline{TS\text{-}6}$
d. Either the camera-storage looper or the read-out looper is not empty — $\left\{\begin{array}{l}\overline{CLE}\\ \overline{RLE}\end{array}\right.$

If the above four conditions are present, then the camera-motor reverse signal depends on the state of the supply looper memory; it is ON when the memory has been set by the supply-looper empty switch (SLE) and is OFF when the memory has been cleared by the supply-looper full switch (SLF). The presence of this signal enables the camera-motor ON signal (CAS-5).

2.5.2.2.8 24-Inch Shutter Action (CAS-8) (Sheet 7) and Time Code Interrogation (TCI) (Sheet 7)

$$TCI = CAS\text{-}8 = CAS\text{-}4 \cdot SST \cdot CAS\text{-}2\ INT + \overline{CAS\text{-}4} \cdot CAS\text{-}2\ INT\ delayed$$

$$= TS\text{-}4 \cdot (CAS\text{-}4 \cdot IMC \cdot SST + \overline{CAS\text{-}4} \cdot INT\ clock\ delayed)$$

These two signals are present at a one-to-one ratio with respect to film-clamp and draw-vacuum ON (CAS-2 INT), with a lag introduced by the shutter-start signal (SST) in the case of V/H Control (CAS-4) or by the delayed internal clock input when not in the V/H mode ($\overline{\text{CAS-4}}$). Note: These signals are enabled by the camera-memory ON condition (TS-4).

2.5.2.2.9 Read-out Relay in Read-out State (CAS-10) (Sheet 5)

$$CAS\text{-}10 = TS\text{-}6$$

This signal tracks the read-out enable signal TS-6.

2.5.2.2.10 Read-out Clutch Disengaged (CAS-11) (Sheet 5)

$$CAS\text{-}11 = BME + TS\text{-}5$$

This signal tracks Bimat motor enable (BME) prior to Bimat clear and tracks the wind-forward memory (TS-5) after Bimat clear. See these two signals for conditions.

2.5.2.2.11 Supply Brake Disengaged (CAS-12) (Sheet 2)

$$CAS\text{-}12 = CAS\text{-}13 + \overline{TS\text{-}2} \cdot (BMC \cdot TS\text{-}5 + \overline{BMC}) \cdot \overline{SLF}$$

This signal is available only if the solar-eclipse memory is not ON ($\overline{\text{TS-2}}$). Prior to Bimat clear ($\overline{\text{BMC}}$) it occurs when the supply looper is not full ($\overline{\text{SLF}}$).

After Bimat clear (BMC) it occurs if either of the following conditions is in effect:

a. The wind-forward memory is ON and the supply looper is not full — $TS\text{-}5 \cdot \overline{SLF}$

b. The supply-motor ON signal is present — CAS-13

2.5.2.2.12 <u>Supply Motor ON (Reverse ONLY) (CAS-13) (Sheet 2)</u>

$$CAS\text{-}13 = \lfloor SLF * \overline{SLE} \rfloor \cdot BMC \cdot \overline{TS\text{-}2} \cdot \overline{TS\text{-}5}$$

The supply-motor ON signal (reverse) is enabled only if all of the following conditions are in effect:

a. The Bimat has been cut and is clear — BMC

b. The wind-forward memory is not ON — $\overline{TS\text{-}5}$

c. The solar-eclipse memory is not ON — $\overline{TS\text{-}2}$

If the above three conditions are present, then the supply-motor ON signal depends on the state of the supply-looper memory; it is ON when the memory has been set by the supply looper full switch (SLF) and is OFF when the memory has been cleared by the supply looper empty switch (SLE). The presence of this signal disengages the supply brake (see CAS-12).

2.5.2.2.13 <u>Take-Up Motor Forward (CAS-14) (Sheet 2)</u>

$$CAS\text{-}14 = \overline{BMC} \cdot \overline{TS\text{-}6} \cdot TS\text{-}8 + BMC \cdot TS\text{-}5 \quad (\overline{CLE} + \overline{RLE})$$

This signal is present prior to Bimat clear ($\overline{BMC}$) provided: (1) the read-out enable signal is not ON ($\overline{TS\text{-}6}$), and (2) the take-up forward enable signal is ON (TS-8).

After Bimat clear (BMC) this signal is present provided: (1) wind-forward memory is ON (TS-5), and (2) either the camera storage looper or the read-out looper is not empty ($\overline{\text{CLE}}$ + $\overline{\text{RLE}}$).

The present of this signal enables the take-up motor ON signal (CAS-16).

2.5.2.2.14 <u>Take-Up Motor Reverse (CAS-15) (Sheet 2)</u>

$$\text{CAS-15} = \lfloor \text{TLE} * \overline{\text{TLF}} \rfloor \cdot \overline{\text{TS-5}} \cdot (\text{BMC} + \text{TS-6}) \cdot \overline{\text{RLF}}$$

The take-up motor reverse signal is enabled after Bimat clear (BMC) if the wind-forward memory is not ON ($\overline{\text{TS-5}}$); prior to Bimat clear, state $\overline{\text{TS-5}}$ is always present and CAS-15 is enabled only if the read-out enable signal is ON (TS-6). In all cases the read-out looper must be not full ($\overline{\text{RLF}}$).

If an enable condition exists then the take-up motor reverse signal depends upon the state of the take-up looper memory; it is ON when the memory has been set by the take-up looper empty switch (TLE) and is OFF when the memory has been cleared by the take-up looper full switch (TLF).

The presence of CAS-15 enables the take-up motor ON signal (CAS-16).

2.5.2.2.15 <u>Take-Up Motor ON (CAS-16) (Sheet 2)</u>

$$\text{CAS-16} = \overline{\text{TS-2}} \cdot (\text{CAS-14} + \text{CAS-15})$$

This signal is generated by either (1) take-up motor forward (CAS-14) or (2) take-up motor reverse (CAS-15) provided the solar eclipse memory is OFF ($\overline{\text{TS-2}}$). Onset of the signal is delayed by a single-shot circuit. Prior to Bimat clear the direction is controlled by the read-out enable signal (TS-6); after Bimat clear the direction is controlled by the wind-forward memory (TS-5).

2.5.2.2.16 ±20V and +6.3V Converters ON (CAS-17) (Sheet 4)

CAS-17 = TS-6 + CAS-4

This signal is present if either of the following is in effect:

| | | |
|---|---|---|
| a. | Read-out enable ON | TS-6 |
| b. | -V/H memory ON | CAS-4 |

The onset of this signal is delayed by a single-shot circuit. The destination of the converter outputs is determined by the state of the read-out relay, which is controlled by mutually exclusive conditions:

| | | |
|---|---|---|
| a. | Read-out state (TS-6) | CAS-10 |
| b. | V/H state | CAS-4 |

2.5.2.2.17 Day Heater Inhibit (CAS-18) (Sheet 4)

CAS-18 = TS-4 + TS-6 + RTC-9 + CBC

The heaters are inhibited if any of the following conditions is in effect:

| | | |
|---|---|---|
| a. | The camera memory is ON | TS-4 |
| b. | The read-out enable is ON | TS-6 |
| c. | Heater-inhibit command is ON | RTC-9 |
| d. | Cut-Bimat command memory is ON | CBC |

This signal affects all heaters except those in the Processor/Dryer (see CAS-19).

2.5.2.2.18 Night Heater Inhibit (CAS-19) (Sheet 4)

$$CAS\text{-}19 = CAS\text{-}18 + TS\text{-}2$$

In addition to being established by any of the conditions imposed upon CAS-18, the night heater inhibit is also present if the solar-eclipse memory is ON (TS-2).

2.5.2.2.19 Read-Out High-Voltage ON (CAS-20) (Sheet 5)

$$CAS\text{-}20 = TS\text{-}6$$

Onset of this signal is delayed sufficiently by a single-shot circuit to permit settling of the read-out relay (CAS-10) and converter (CAS-17) signals and to allow warm-up of the line-scan-tube filament.

2.5.2.2.20 Processor/Dryer Heater ON ($\overline{\text{CAS-21}}$) (Sheet 5)

$$\overline{CAS\text{-}21} = BME \cdot \overline{CBC}$$

This signal is established when Bimat motor enable (BME) is present provided the cut-Bimat command memory is OFF ($\overline{\text{CBC}}$).

2.5.2.3 Logic-Dependent Telemetry

2.5.2.3.1 Bimat Cut-and-Clear Telemetry Point (PTL-18) (PC07) (Sheet 5)

$$PTL\text{-}18 = \overline{BMC \cdot BCO}$$

This signal goes low (FALSE) if the Bimat has been cut (BCO) and has cleared the processor drum (BMC).

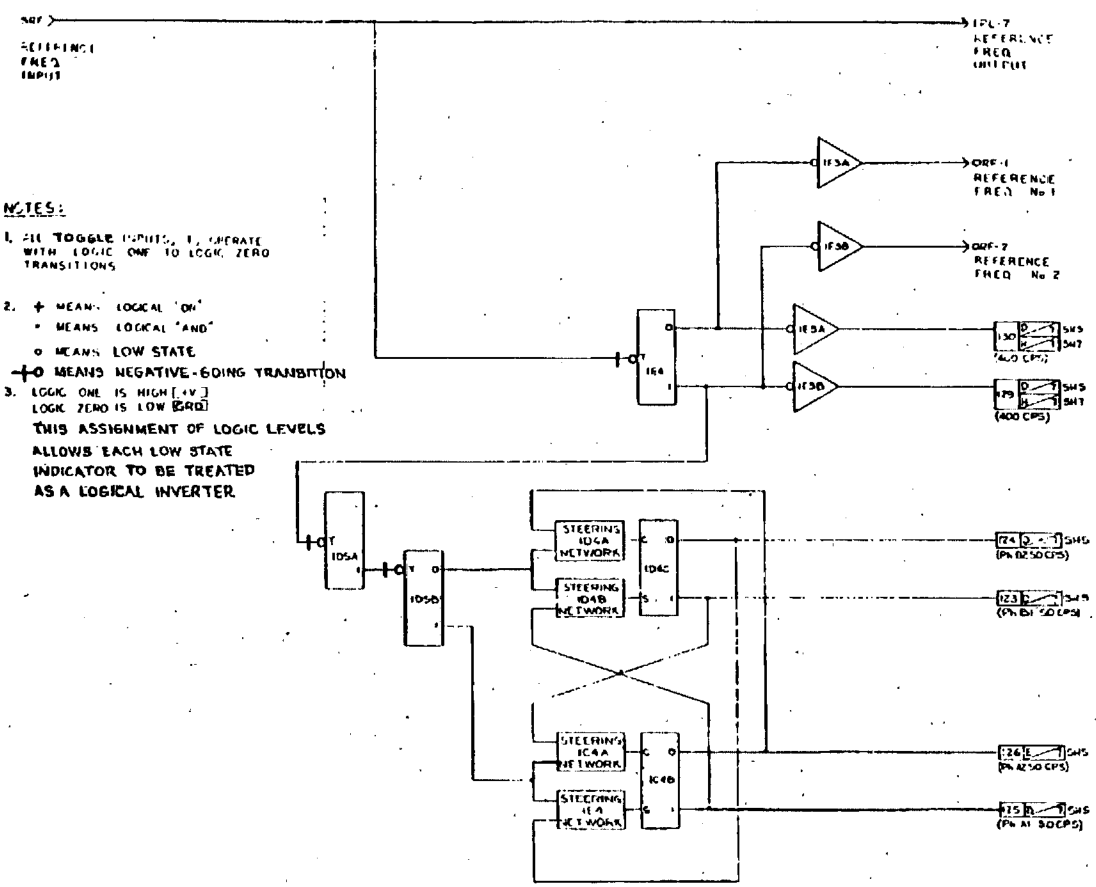
2.5.2.3.2 Camera Rate Memory Fast (CTL-10a) (PC03a) (Sheet 7)

$$\text{CTL-10a} = \underline{(\text{SPC-26} \cdot \overline{\text{TS-4}}) * \overline{\text{SPC-27}}}$$

This memory can be set to the FAST condition by command SPC-26 provided the camera memory is not ON ($\overline{\text{TS-4}}$). It can be cleared to the SLOW condition at any time by command SPC-27.

This memory establishes whether the following signals are generated at a one-to-one (FAST) or one-to-four (SLOW) rate with respect to the film clamp and draw vacuum input (IMC) when under control of the V/H sensor or with respect to the internal clock when not in the V/H mode:

| | | |
|---|---|---|
| a. | Film clamp and draw vacuum ON (this signal is generated at a one-to-one rate, only, when in the V/H mode) | CAS-2 |
| b. | Time code interrogation | TCI |
| c. | 80-mm shutter memory ON | CAS-3 |
| d. | 24-inch shutter action | CAS-8 |
| e. | Camera-motor forward memory ON | CAS-1 |
| f. | Camera motor ON | CAS-5 |



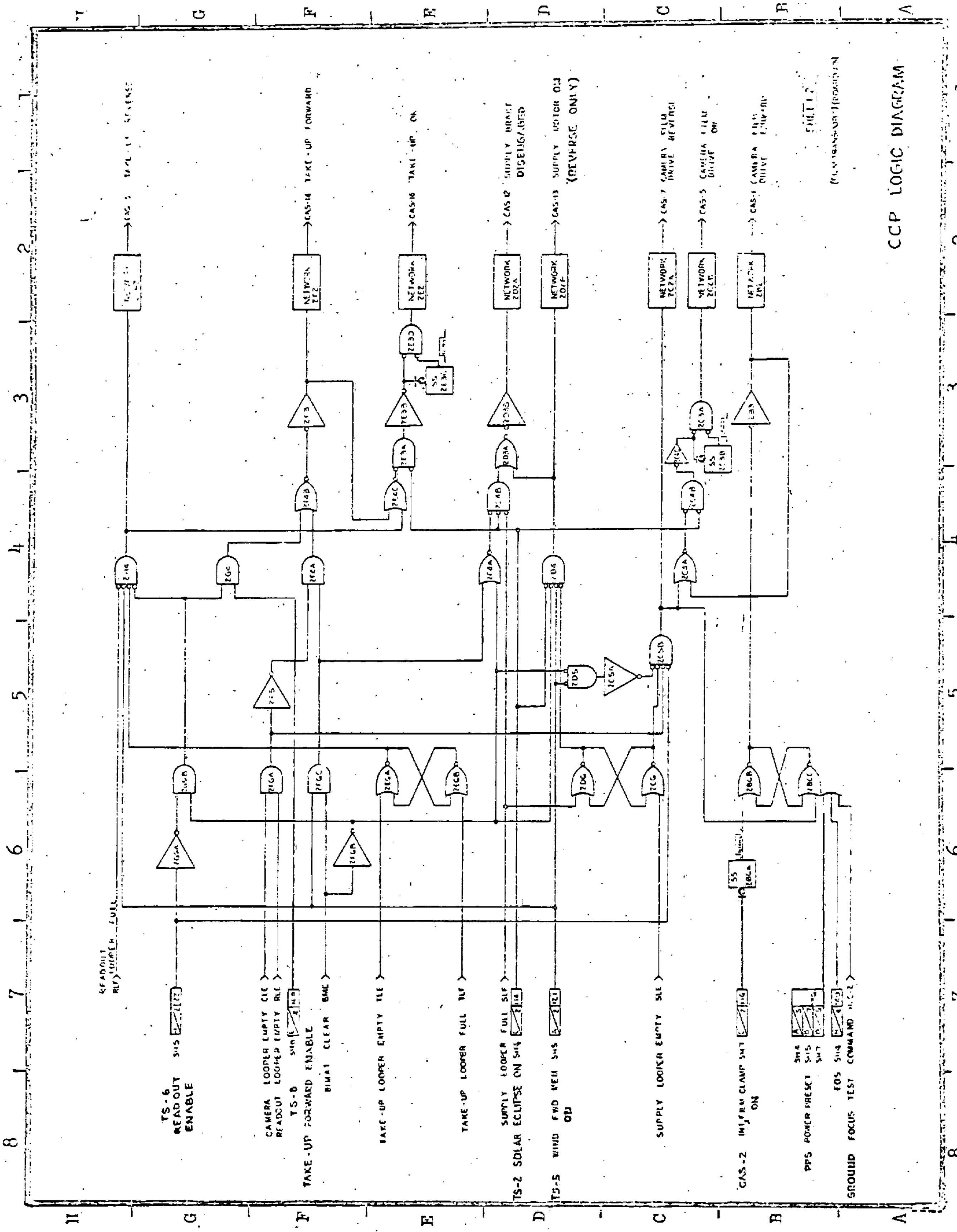

NOTES:

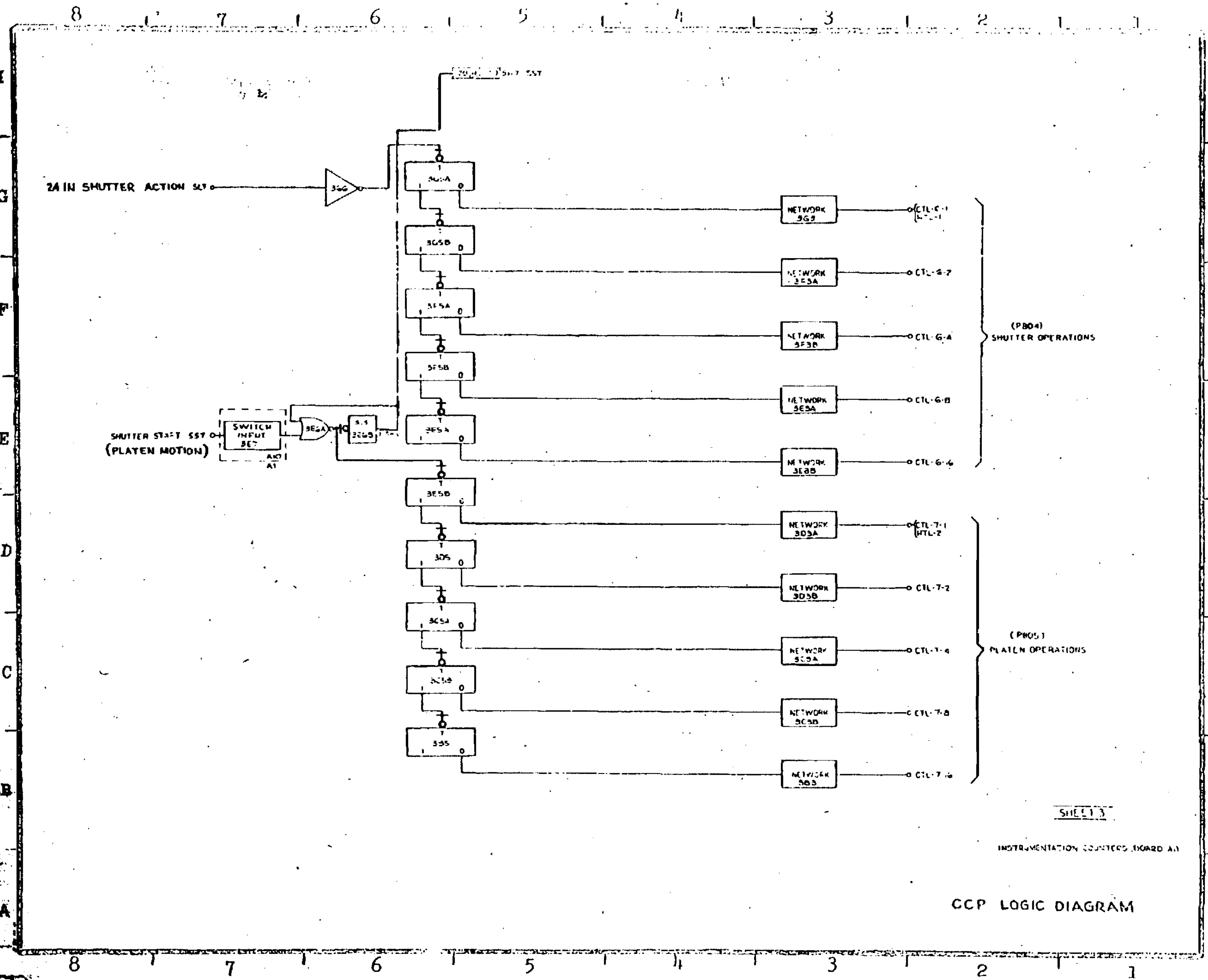
1. ALL TOGGLE INPUTS, T, OPERATE WITH LOGIC ONE TO LOGIC ZERO TRANSITIONS
2. + MEANS LOGICAL 'OR'
   • MEANS LOGICAL 'AND'
   o MEANS LOW STATE
   +o MEANS NEGATIVE-GOING TRANSITION
3. LOGIC ONE IS HIGH [+V]
   LOGIC ZERO IS LOW [GRD]
   THIS ASSIGNMENT OF LOGIC LEVELS ALLOWS EACH LOW STATE INDICATOR TO BE TREATED AS A LOGICAL INVERTER

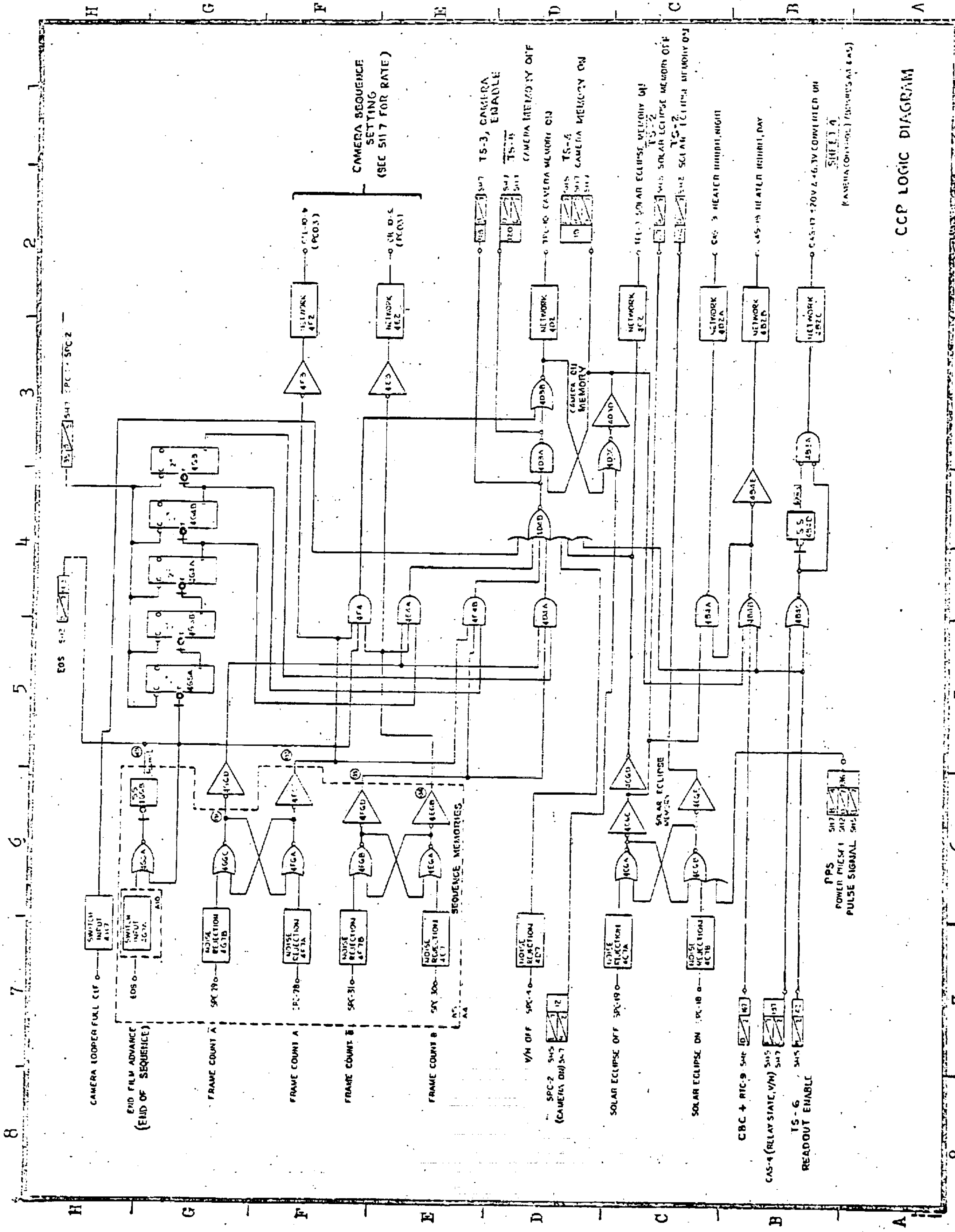
SHEET 1

(BOARD AE)
REFERENCE FREQUENCY & PHASE SPLITTER

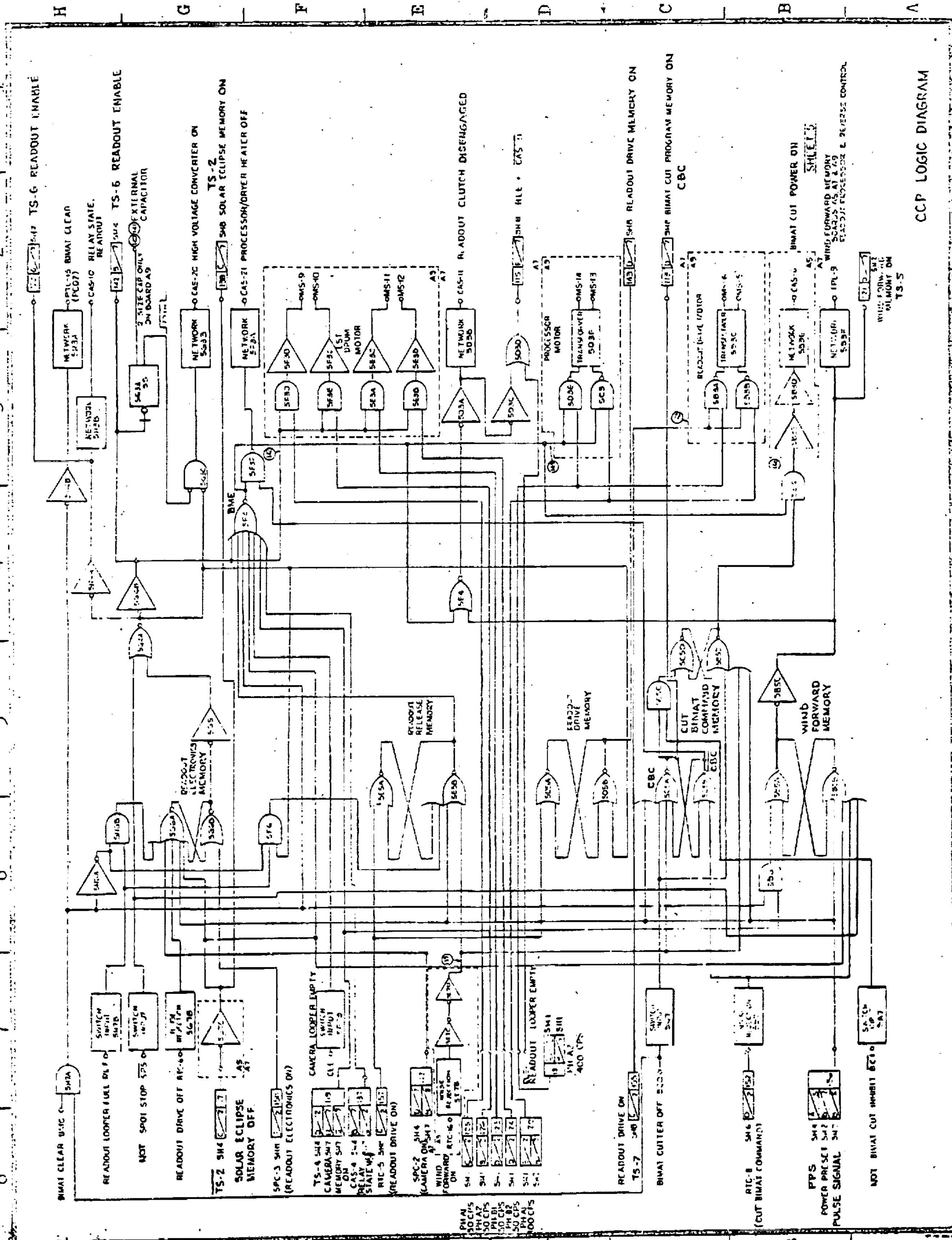
CCP LOGIC DIAGRAM


CCP LOGIC DIAGRAM
TS-6 READOUT ENABLE
CAMERA LOOPER EMPTY CLE
READOUT LOOPER EMPTY RLE
TS-8 TAKE-UP FORWARD ENABLE
BIMAT CLEAR BMC
TAKE-UP LOOPER EMPTY TLE
TAKE-UP LOOPER FULL TLF
SUPPLY LOOPER FULL SLF
TS-2 SOLAR ECLIPSE ON
TS-5 WIND FWD REW ON
SUPPLY LOOPER EMPTY SLE
CAS-2 INTRFRM CLAMP ON
PPS POWER PRESET
EOS
GROUND FOCUS TEST COMMAND
TAKE-UP FORWARD
TAKE-UP ON
SUPPLY BRAKE DISENGAGED
SUPPLY MOTOR ON (REVERSE ONLY)
CAMERA FILM DRIVE REVERSE
CAMERA FILM DRIVE ON
CAMERA FILM DRIVE

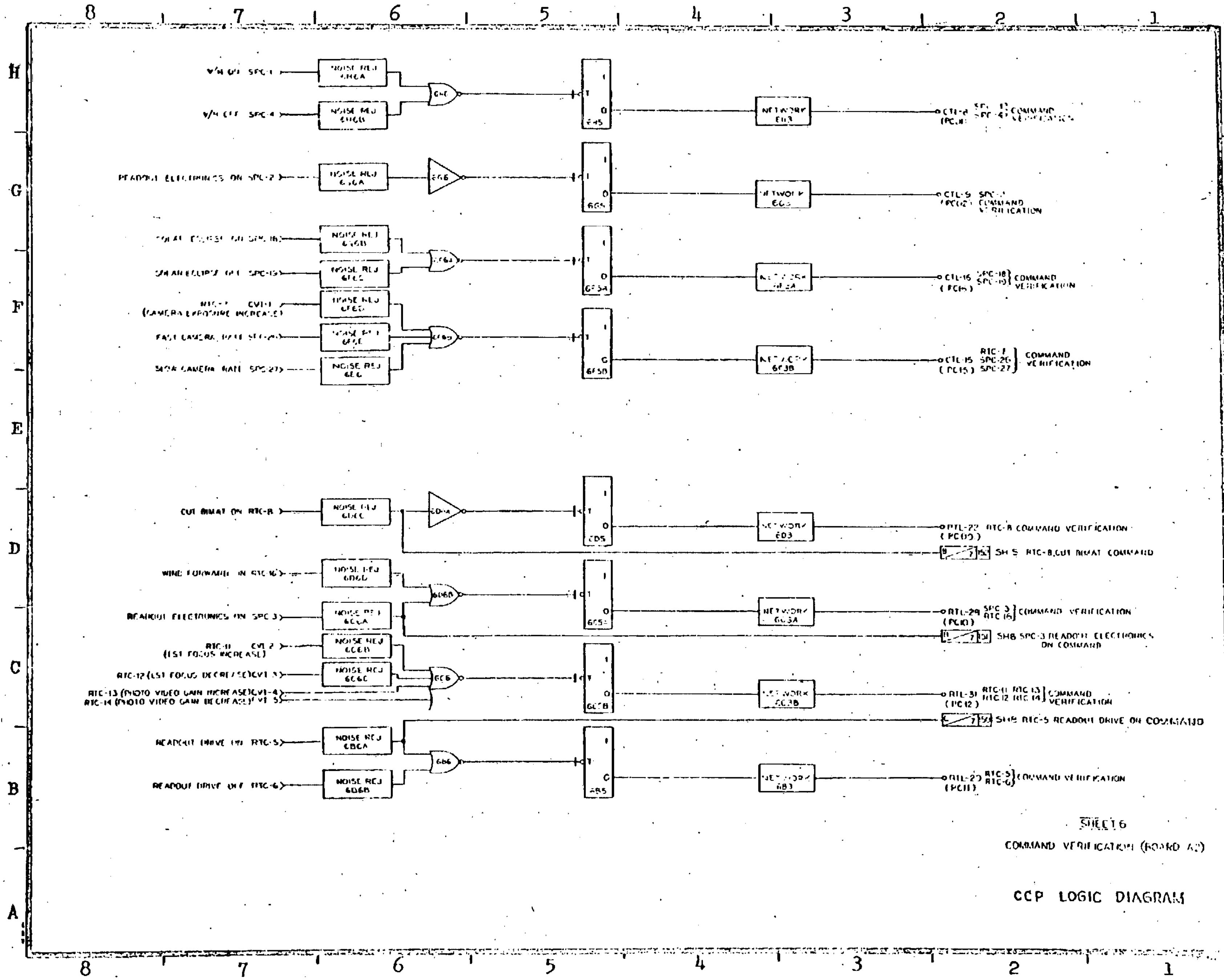

24 IN SHUTTER ACTION SST
SHUTTER START SST
(PLATEN MOTION)
SWITCH INPUT SET
NETWORK 3G3
NETWORK 3E5A
NETWORK 3F3B
NETWORK 3E5A
NETWORK 3E8B
NETWORK 3D3A
NETWORK 3D3B
NETWORK 3C3A
NETWORK 3C3B
NETWORK 3B3
CTL-6-2
CTL-6-4
CTL-6-8
CTL-6-6
CTL-7-2
CTL-7-4
CTL-7-8
(P804)
SHUTTER OPERATIONS
(P805)
PLATEN OPERATIONS
SHEET 3
INSTRUMENTATION COUNTERS BOARD A1
CCP LOGIC DIAGRAM

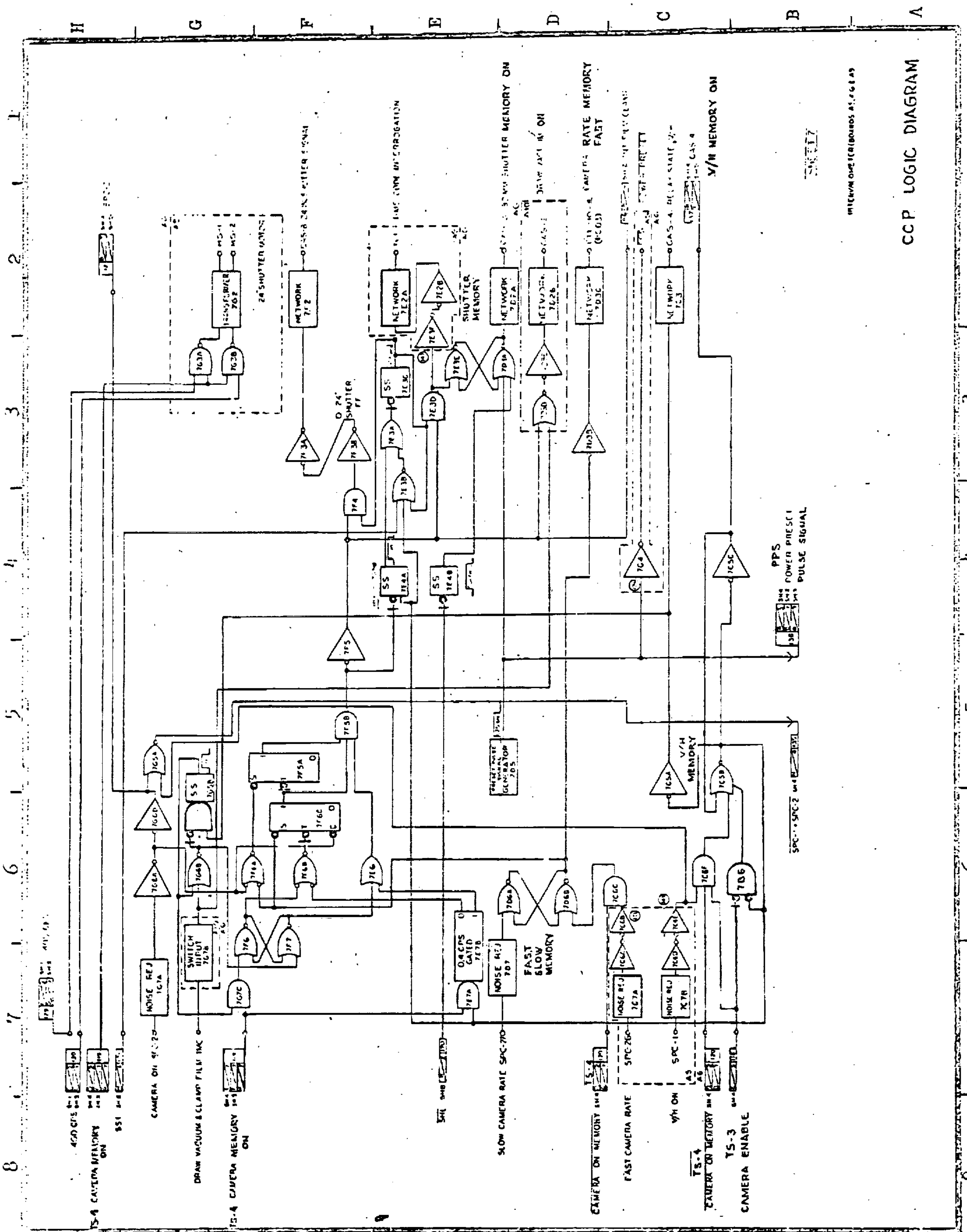


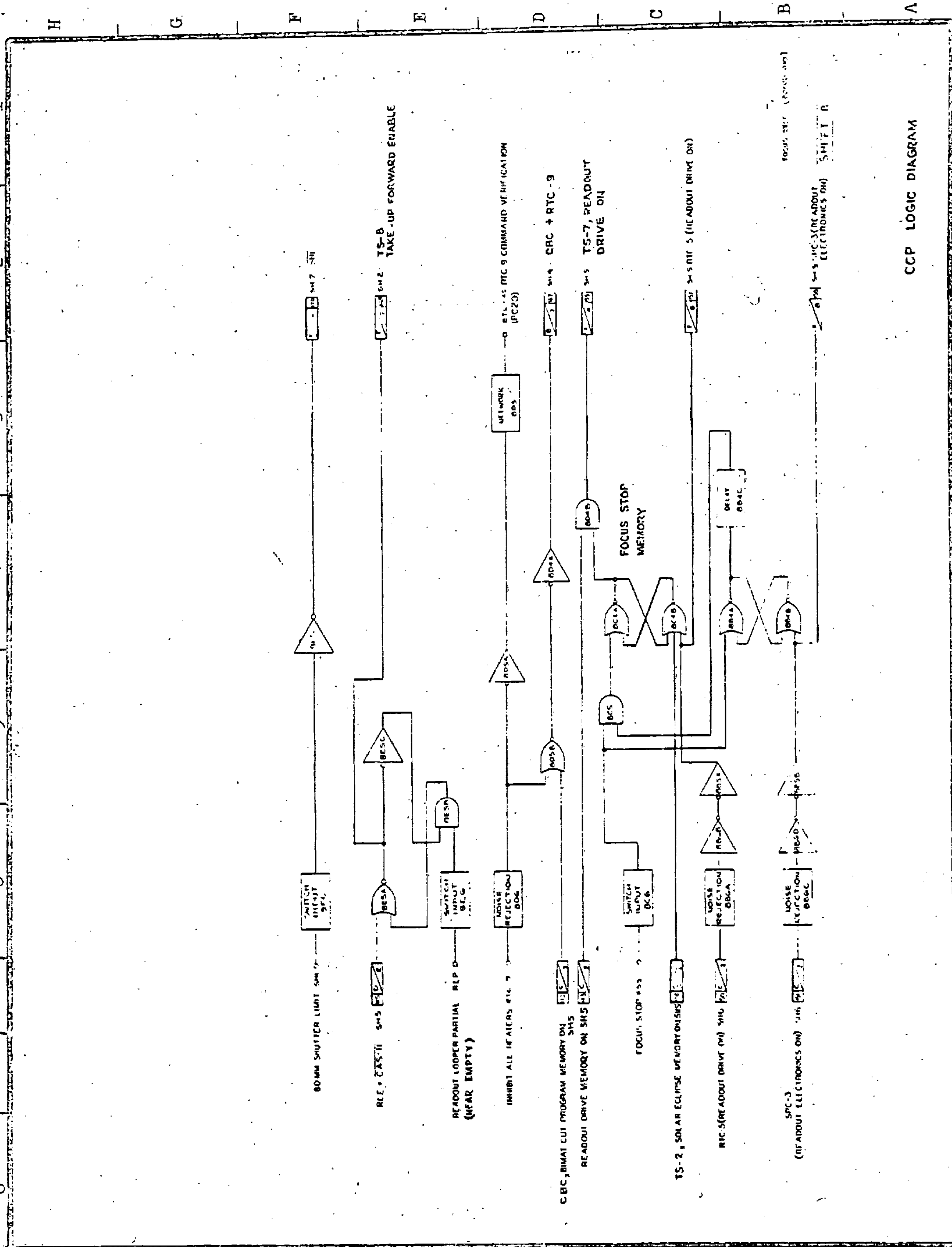

CCP LOGIC DIAGRAM



CCP LOGIC DIAGRAM
TS-6 READOUT ENABLE
TS-6 READOUT ENABLE
EXTERNAL CAPACITOR
CAS-2C HIGH VOLTAGE CONVERTER ON
TS-2
SOLAR ECLIPSE MEMORY ON
CAS-21 PROCESSOR/DRYER HEATER OFF
READOUT CLUTCH DISENGAGED
READOUT DRIVE MEMORY ON
BIMAT CUT PROGRAM MEMORY ON
CBC
BIMAT CUT POWER ON
PROCESSOR MOTOR
BME
READOUT ELECTRONICS MEMORY
READOUT RELEASE MEMORY
READOUT DRIVE MEMORY
CUT BIMAT COMMAND MEMORY
WIND FORWARD MEMORY
BIMAT CLEAR
READOUT LOOPER FULL
NOT SPOOL STOP
READOUT DRIVE OFF
TS-2
SOLAR ECLIPSE MEMORY OFF
(READOUT ELECTRONICS ON)
CAMERA LOOPER EMPTY
(READOUT DRIVE ON)
(CAMERA ON)
WIND FORWARD ON
READOUT LOOPER EMPTY
READOUT DRIVE ON
TS-7
BIMAT CUTTER OFF
(CUT BIMAT COMMAND)
PPS
POWER PRESET PULSE SIGNAL
NOT BIMAT CUT INHIBIT


READOUT ELECTRONICS ON SPC-2
CUT BIMAT ON RTC-8
READOUT ELECTRONICS ON SPC-3
RTC-12 (LST FOCUS DECREASE)CVT-3
RTC-13 (PHOTO VIDEO GAIN INCREASE)CVT-4
RTC-14 (PHOTO VIDEO GAIN DECREASE)CVT-5
READOUT DRIVE ON RTC-5
READOUT DRIVE OFF RTC-6
NOISE REJ
NETWORK
COMMAND VERIFICATION
RTL-22 RTC-8 COMMAND VERIFICATION
SH 5 RTC-8,CUT BIMAT COMMAND
SH8 SPC-3 READOUT ELECTRONICS ON COMMAND
SH5 RTC-5 READOUT DRIVE ON COMMAND
SHEET 6
COMMAND VERIFICATION (BOARD A2)
CCP LOGIC DIAGRAM


CCP LOGIC DIAGRAM
V/H MEMORY ON
CAMERA RATE MEMORY FAST
SHUTTER MEMORY
FAST SLOW MEMORY
V/H MEMORY
PPS POWER PRESET PULSE SIGNAL
TS-3 CAMERA ENABLE
TS-4 CAMERA ON MEMORY
CAMERA ON MEMORY
FAST CAMERA RATE
SLOW CAMERA RATE SPC-70
V/H ON
DRAW VACUUM & CLAMP FILM INC
TS-4 CAMERA MEMORY ON
CAMERA ON
400 CPS
NOISE REJ
SWITCH INPUT
NETWORK
SS


80MM SHUTTER LIMIT
SWITCH INPUT
RLE + CAS-II SH5
BESA
BESC
TS-8
TAKE-UP FORWARD ENABLE
READOUT LOOPER PARTIAL RLP
(NEAR EMPTY)
SWITCH INPUT
INHIBIT ALL HEATERS
NOISE REJECTION
806
BD5A
NETWORK
BD5
(PC23)
CBC, BIMAT CUT PROGRAM MEMORY ON SH5
BD5B
BD4A
CBC + RTC-9
READOUT DRIVE MEMORY ON SH5
BD4B
TS-7, READOUT DRIVE ON
BC5
BC4A
FOCUS STOP MEMORY
FOCUS STOP
SWITCH INPUT
BC6
TS-2, SOLAR ECLIPSE MEMORY ON SH5
BC4B
RTC-5(READOUT DRIVE ON)
NOISE REJECTION
BB6A
BB4A
DELAY
BB4C
SPC-3
(READOUT ELECTRONICS ON)
NOISE REJECTION
BB6C
BB4B
ELECTRONICS ON)
CCP LOGIC DIAGRAM

## 2.6 INTERFACE DRAWINGS

For the convenience of the user of this document, the electrical and mechanical interface drawings are reproduced in this section. The thermal interface drawing being quite lengthy is not included.

The corresponding EKC Drawing numbers are as follows:

| | |
|---|---|
| Mechanical Interface | 1225-101 |
| Electrical Interface | 1225-102 |
| Thermal Interface | 1225-105 |

### 2.6.1 Electrical Interface

Figure 2-41 is the electrical interface drawing

### 2.6.2 Mechanical Interface

Figure 2-42 is the mechanical interface drawing.

NOTES:

1. NON MIL STD ABBREVIATIONS
CCP • COMMAND, CONTROL & PROGRAMMING
LST • LINE SCAN TUBE
IMC • IMAGE MOTION COMPENSATION

V/H • VELOCITY/HEIGHT
PS • PHOTO SUBSYSTEM
DESIG • DESIGNATION
PROG • PROGRAM
RO • READ OUT
CV • COMMAND VERIFY

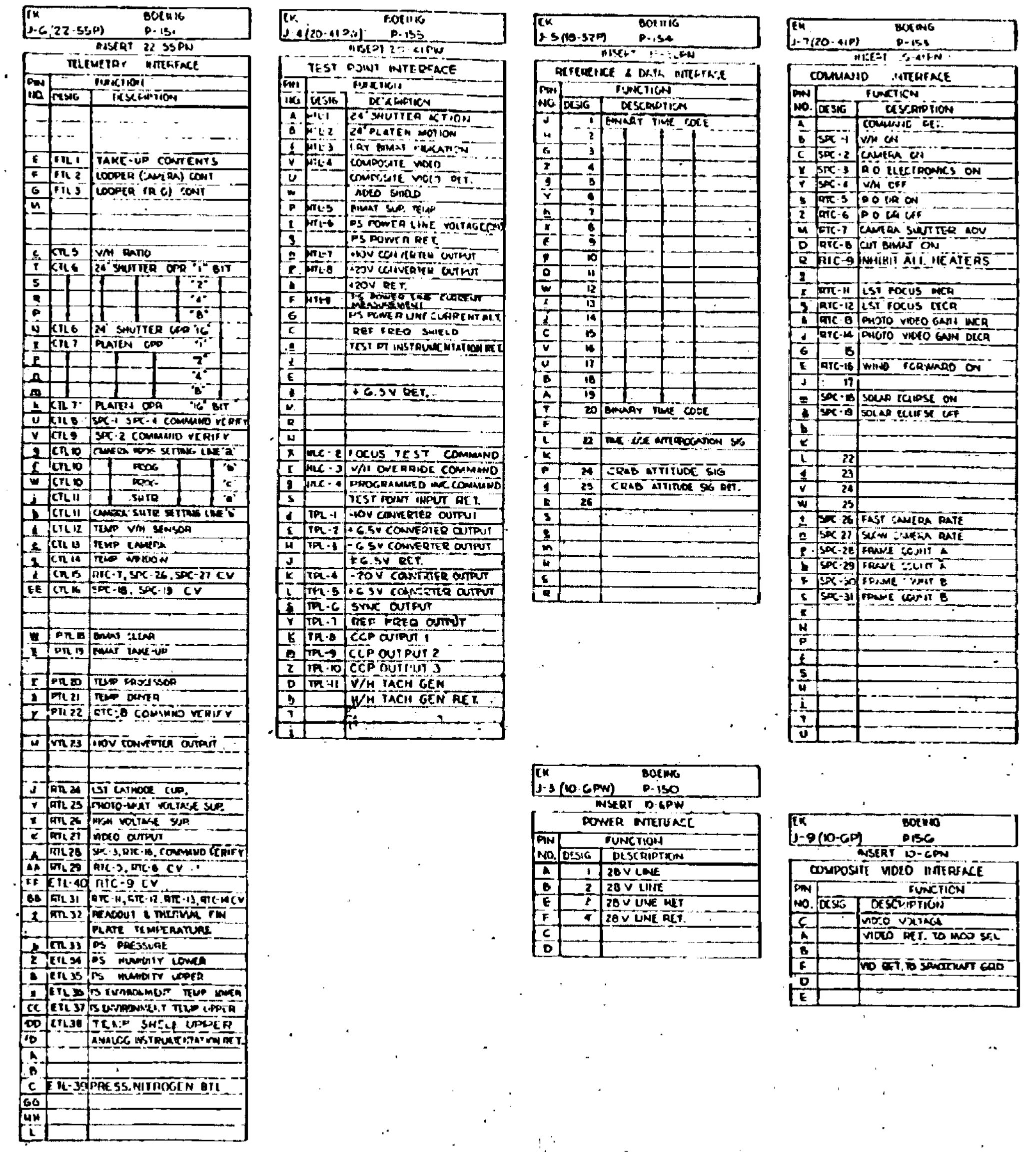



Figure 2-41. Electrical Interface Drawing

L-018375-R

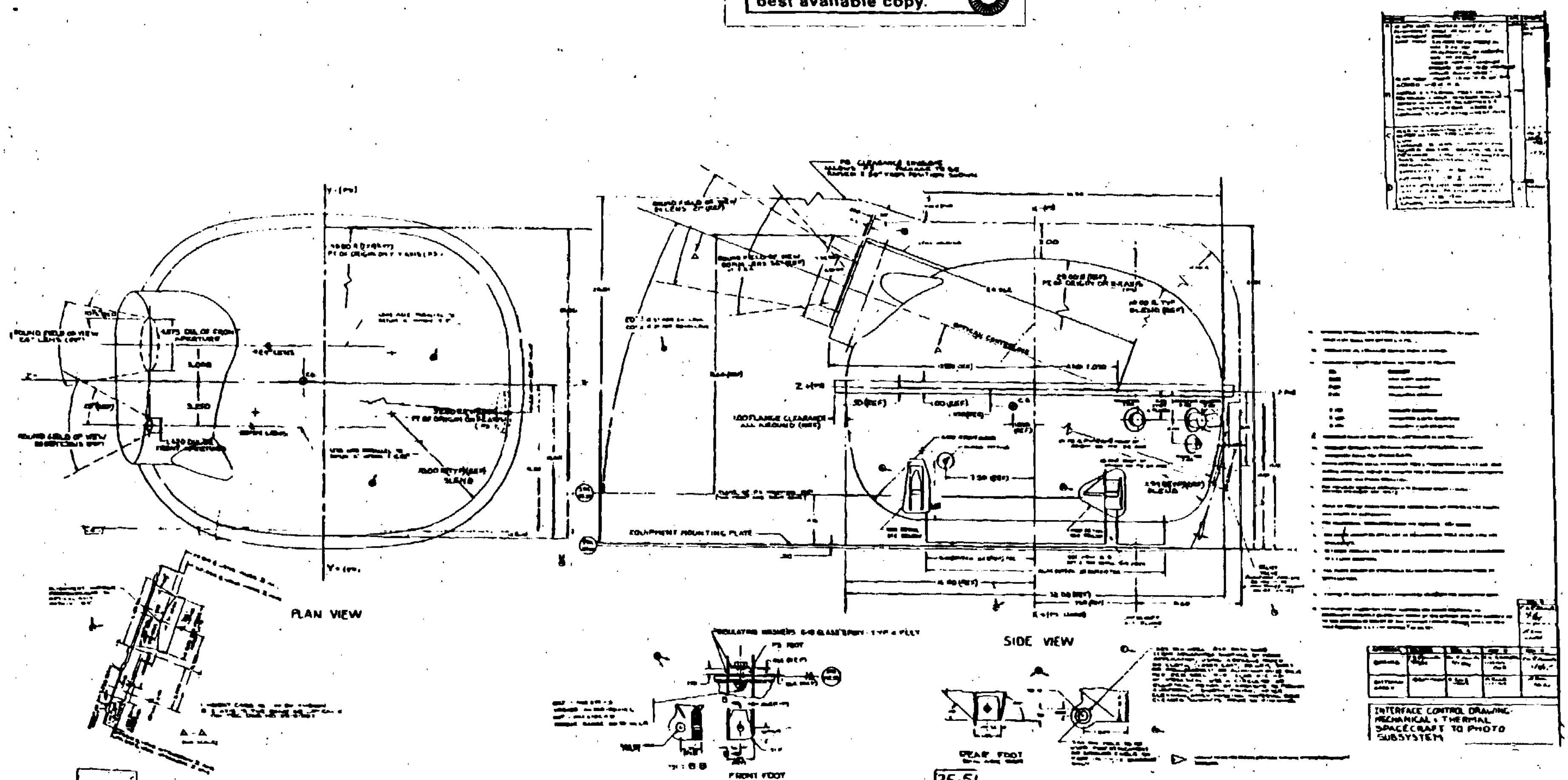



Figure 2-42A. Mechanical Interface Drawing

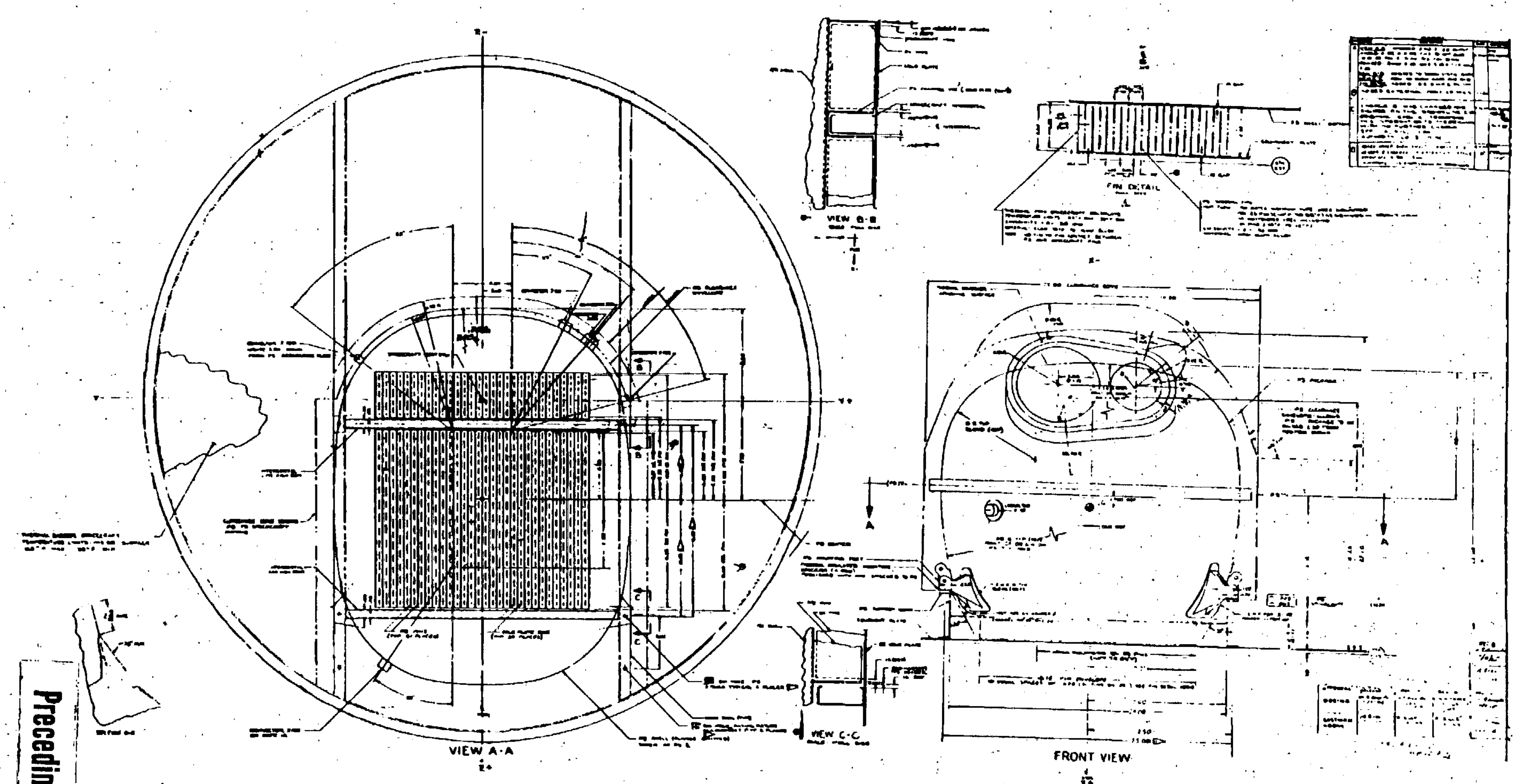



Figure 2-42B. Mechanical Interface Drawing

## 2.7 PHOTOGRAPHS OF THE PHOTOSUBSYSTEM COMPONENTS

In this section, photographs of the PS and various components of the PS are included. Photographs of the film handling and read-out group breadboards are used to illustrate these components, since, as installed in the PS, they are generally hidden from view.

The Photo Subsystem As a Unit

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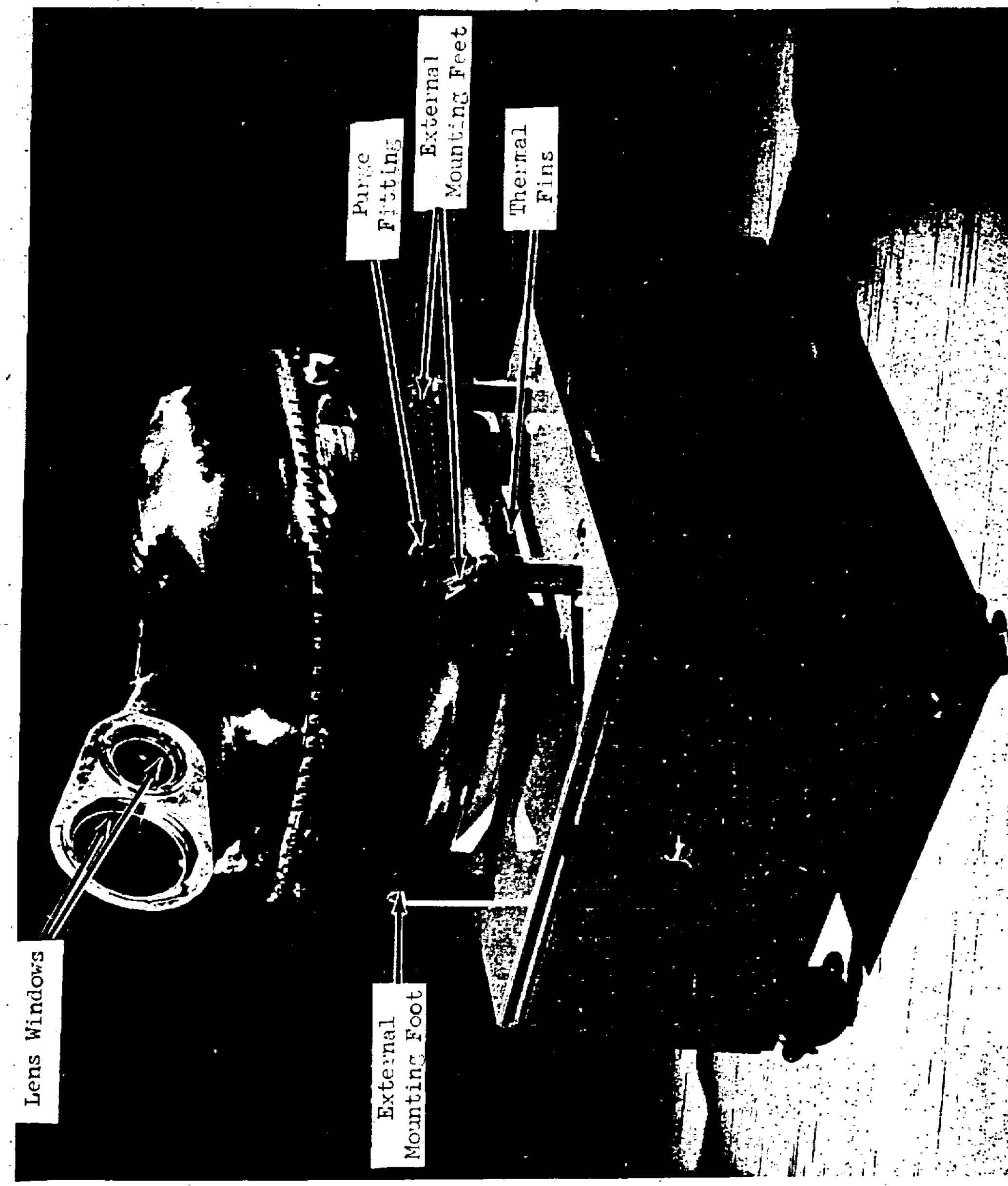


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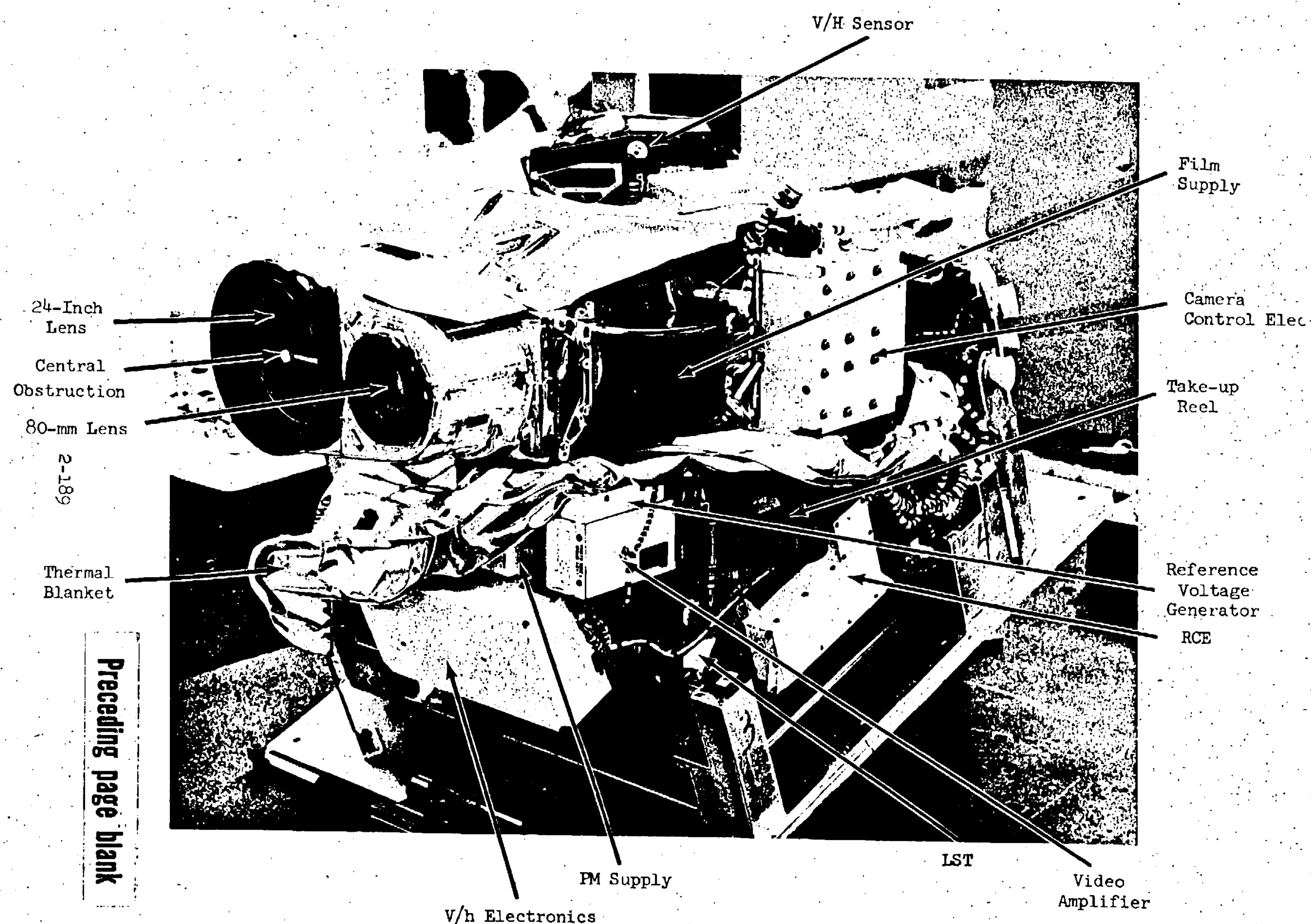


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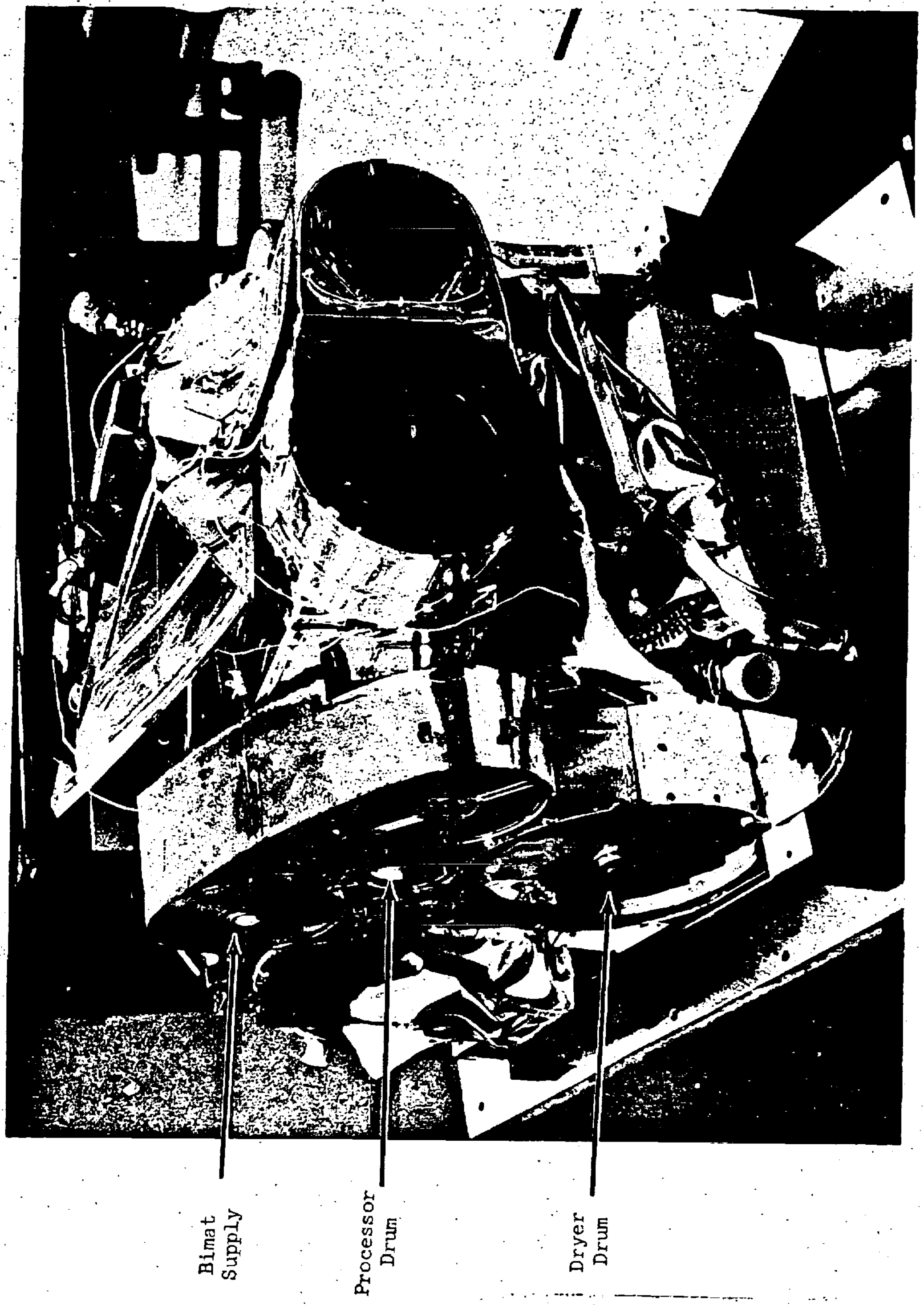
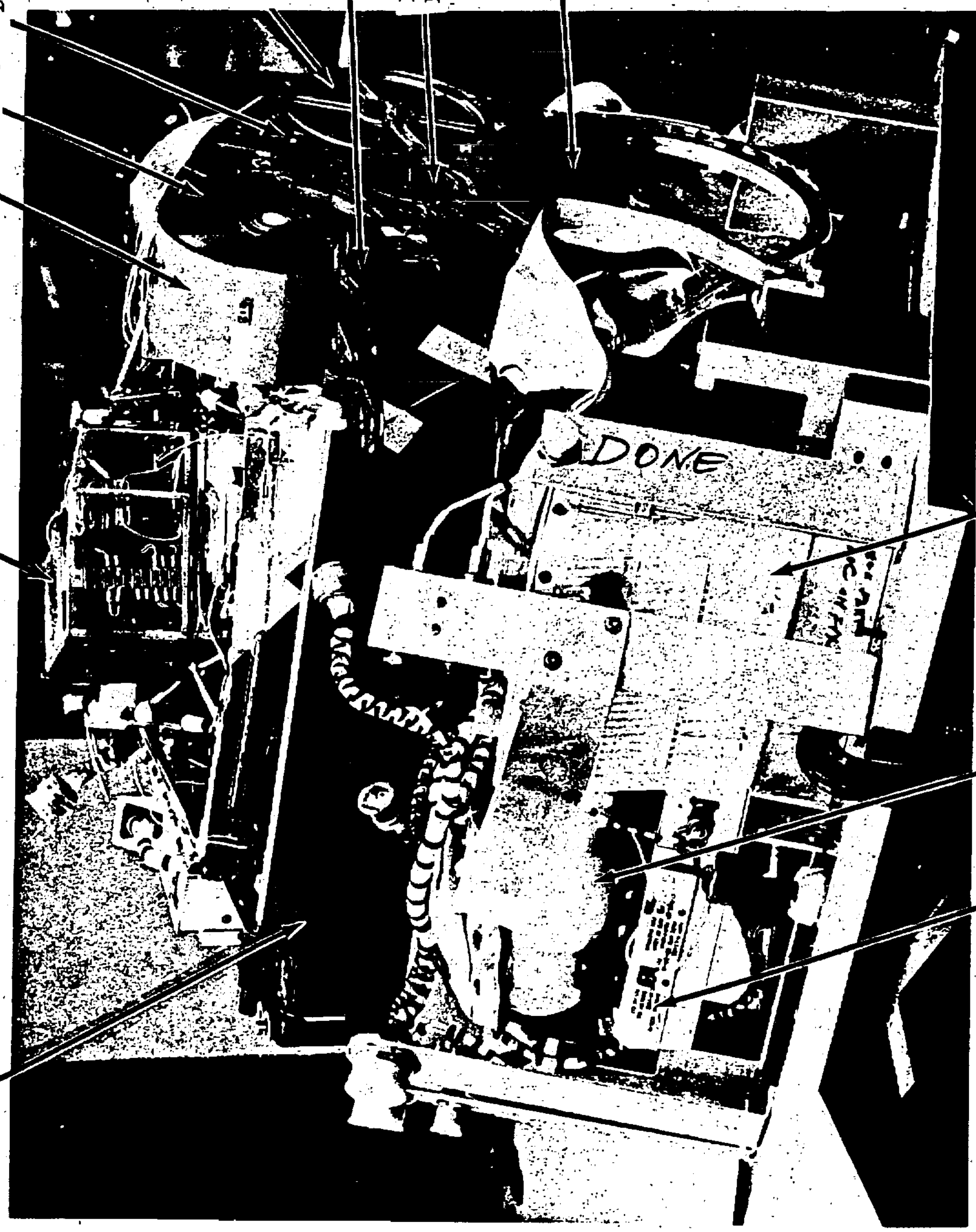

Bimat Supply
Processor Drum
Dryer Drum

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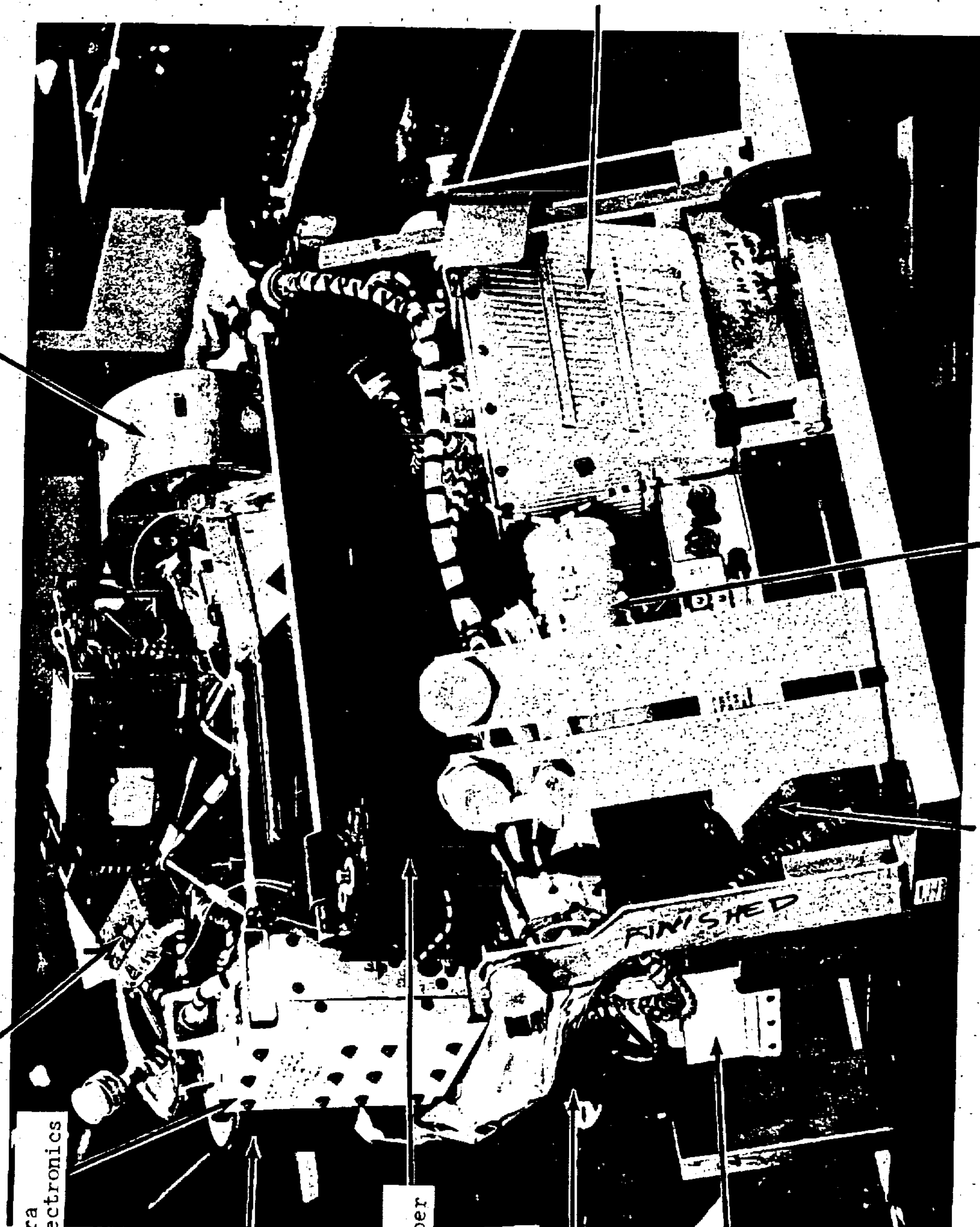


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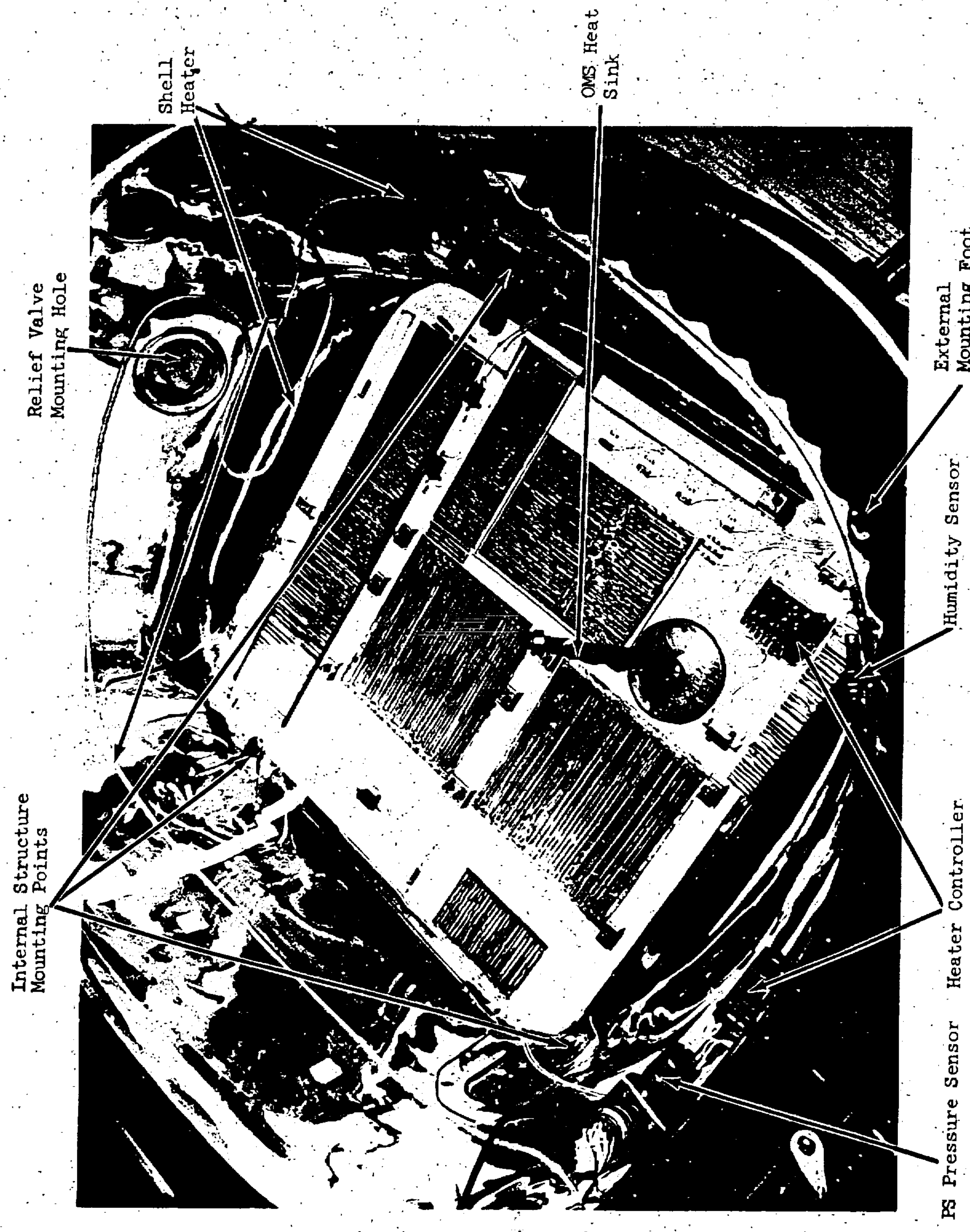


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The Command Control and
Programming (CCP) Unit

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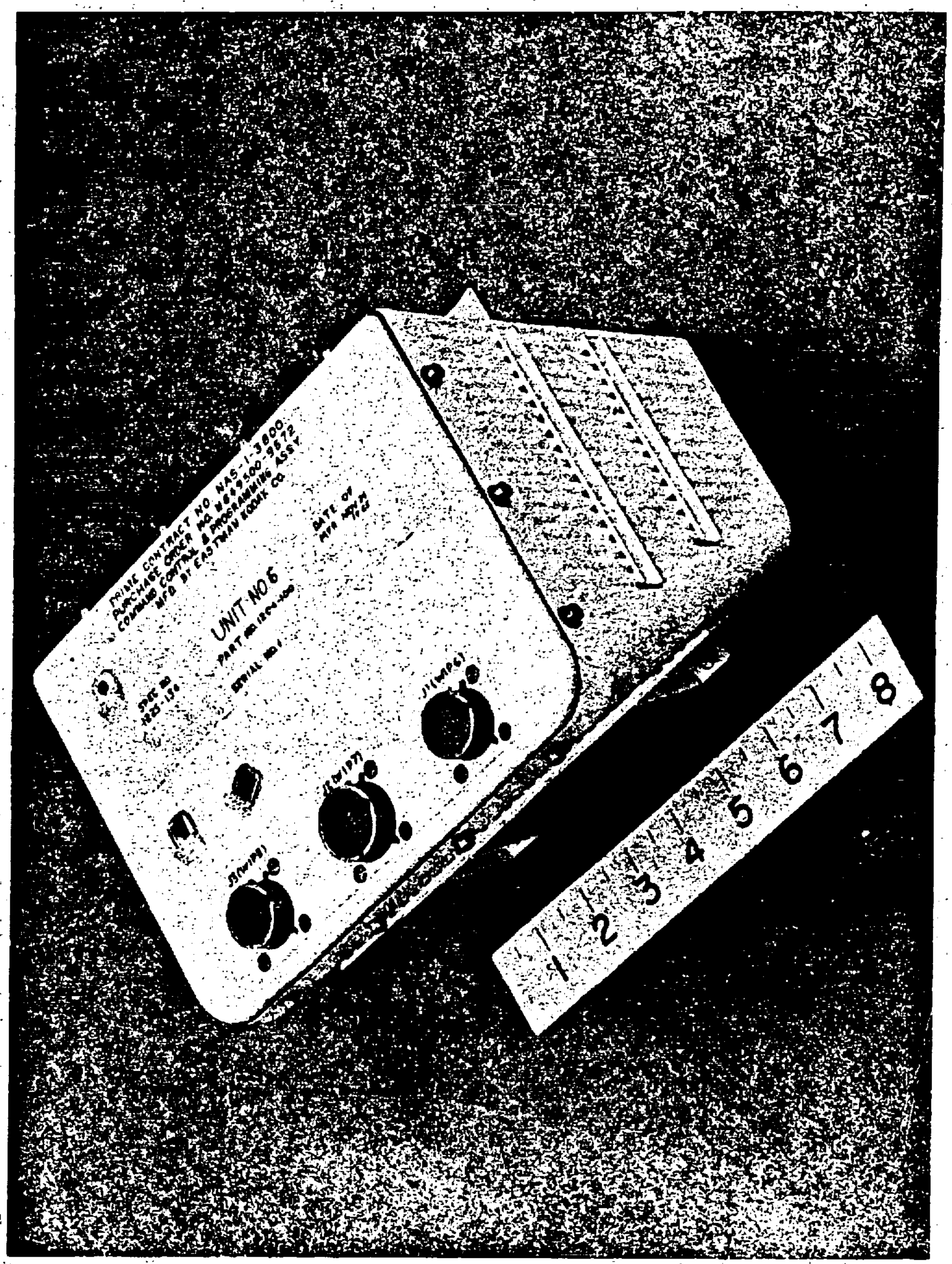


The CCP

# The V/H Sensor

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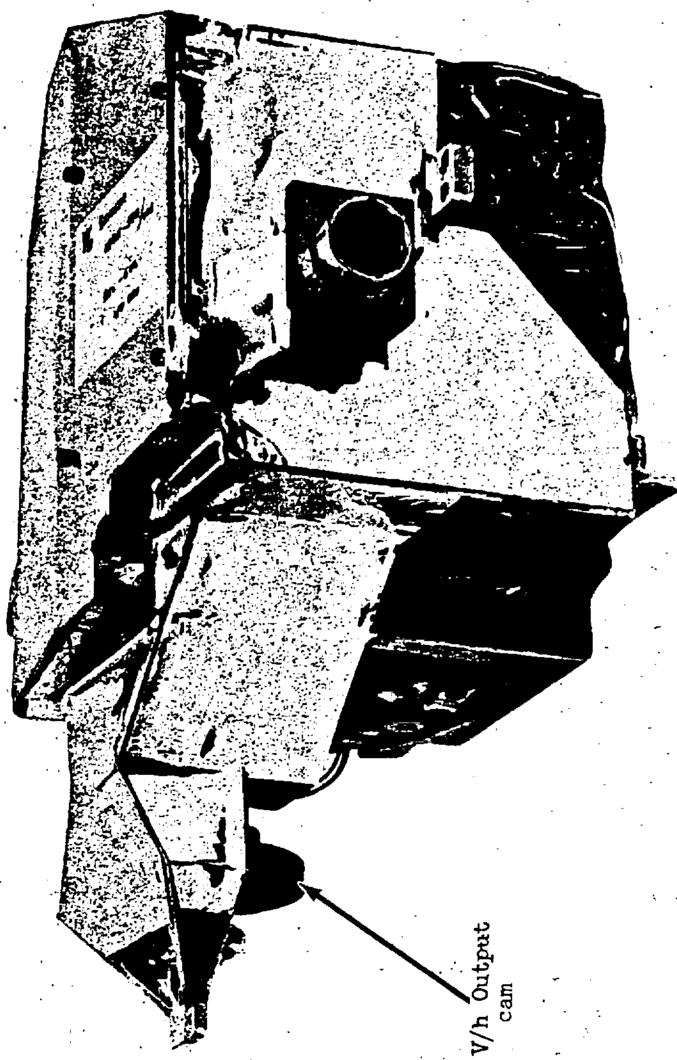


V/h Sensor with Foil Shrouds

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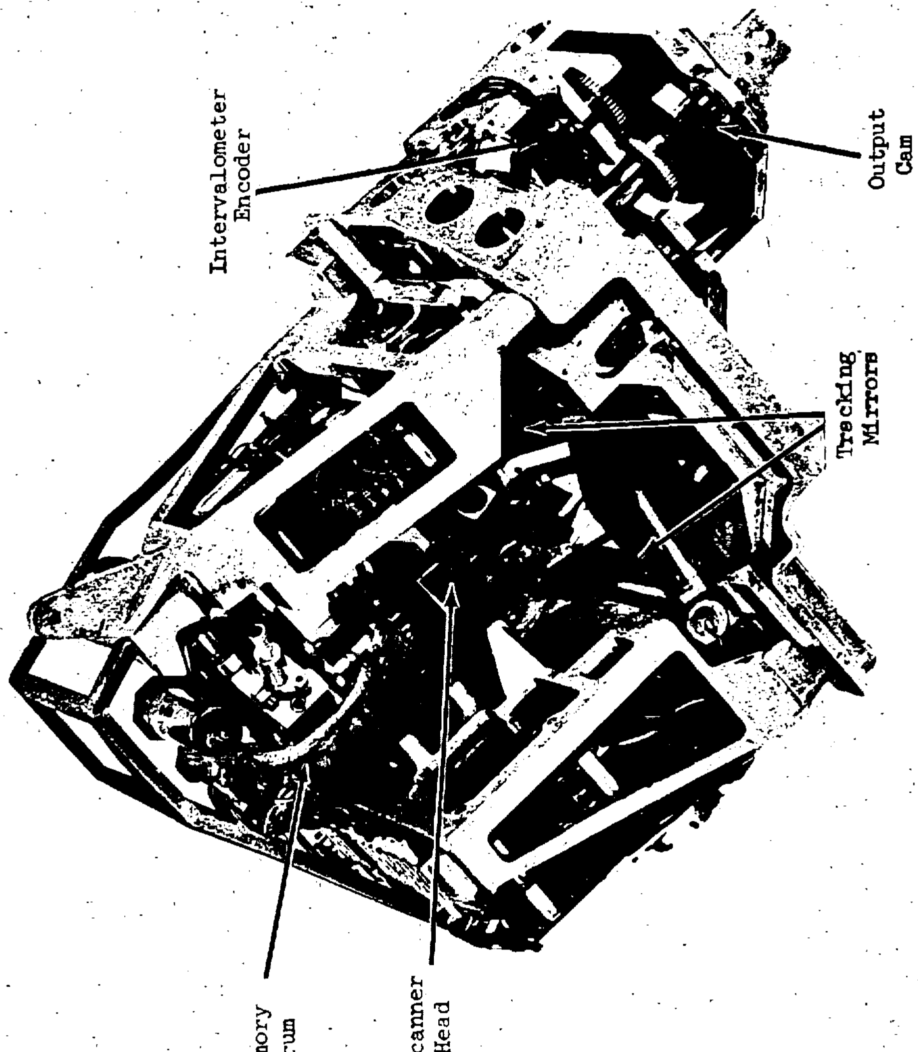


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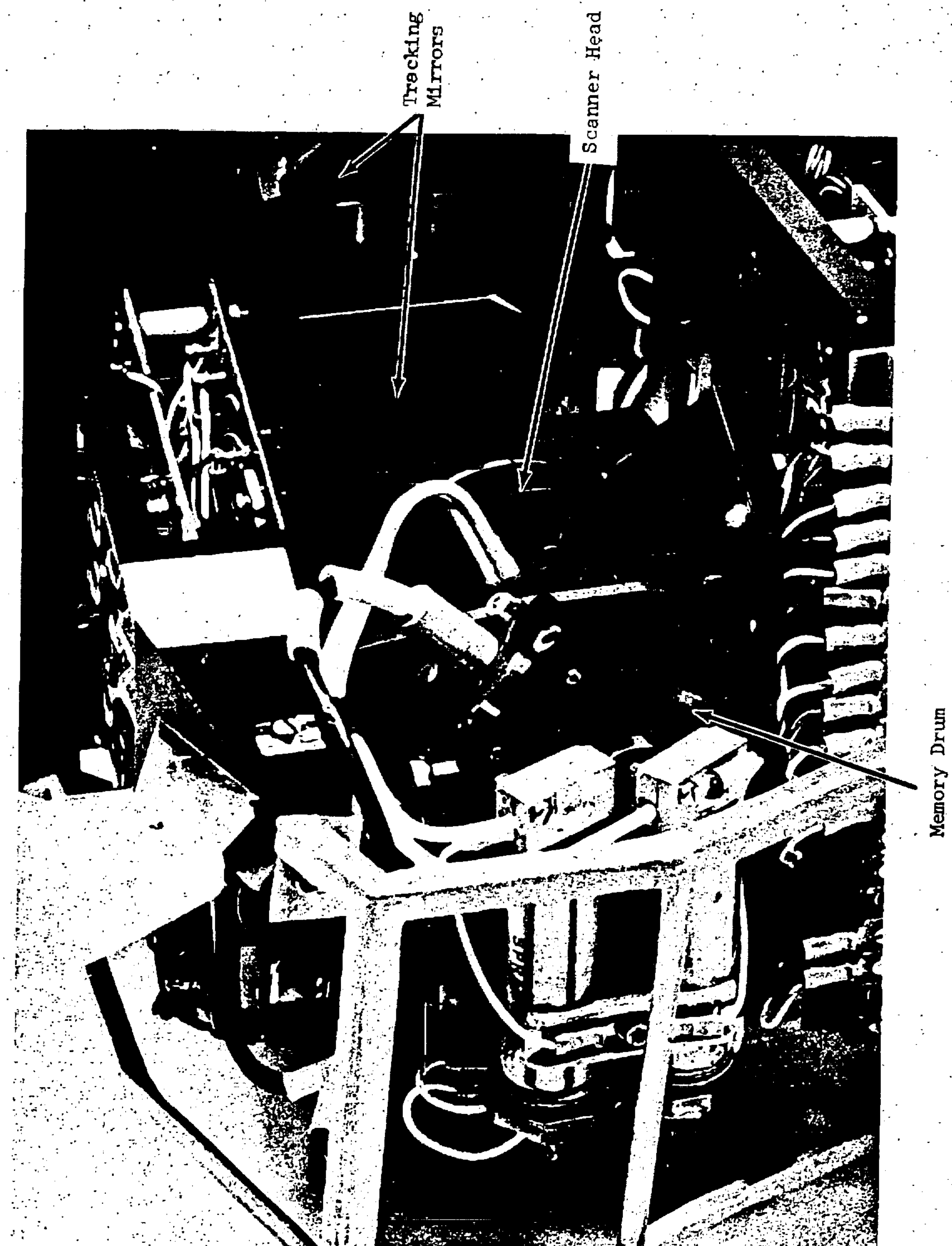


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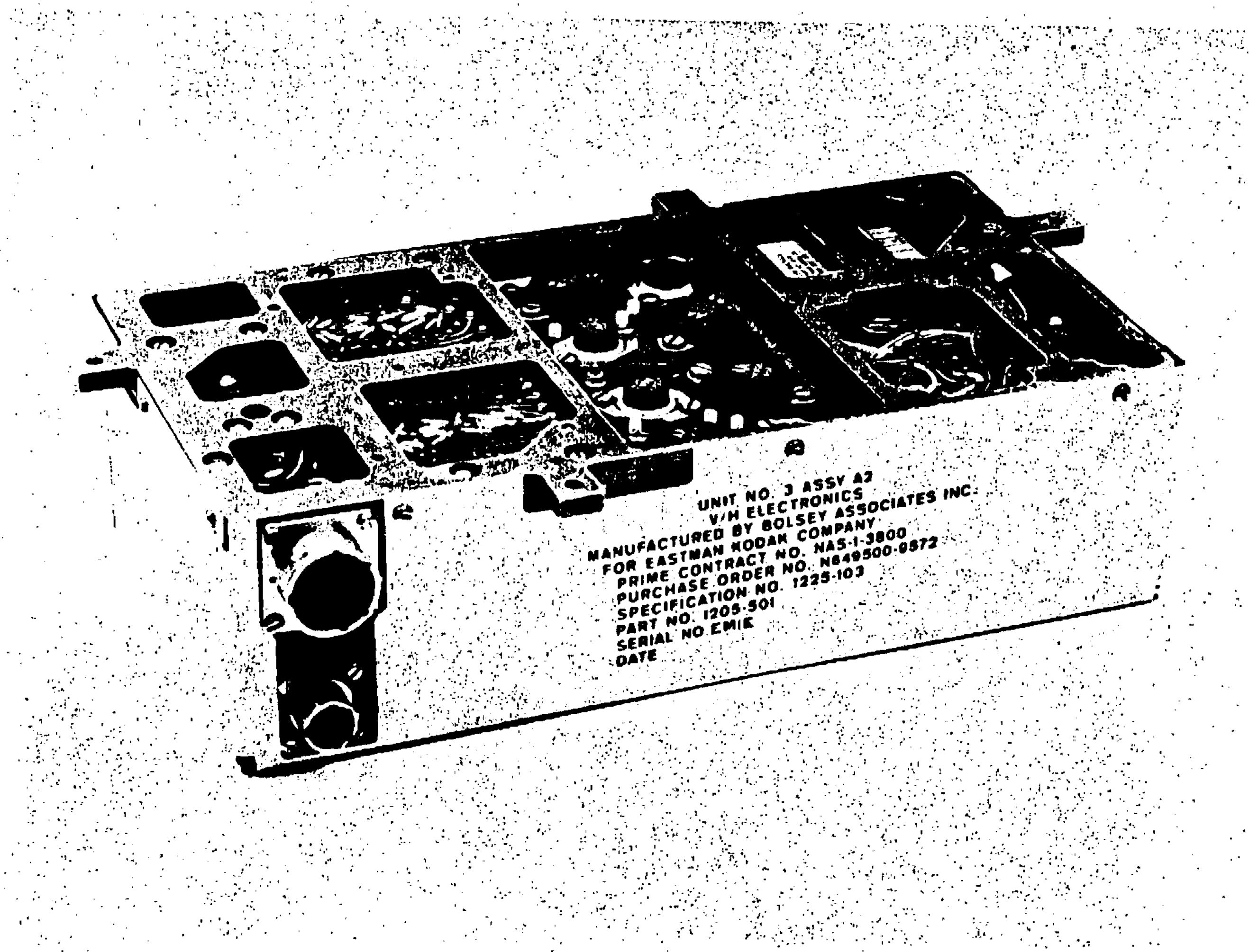


V/H Electronics Assembly

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Camera Components

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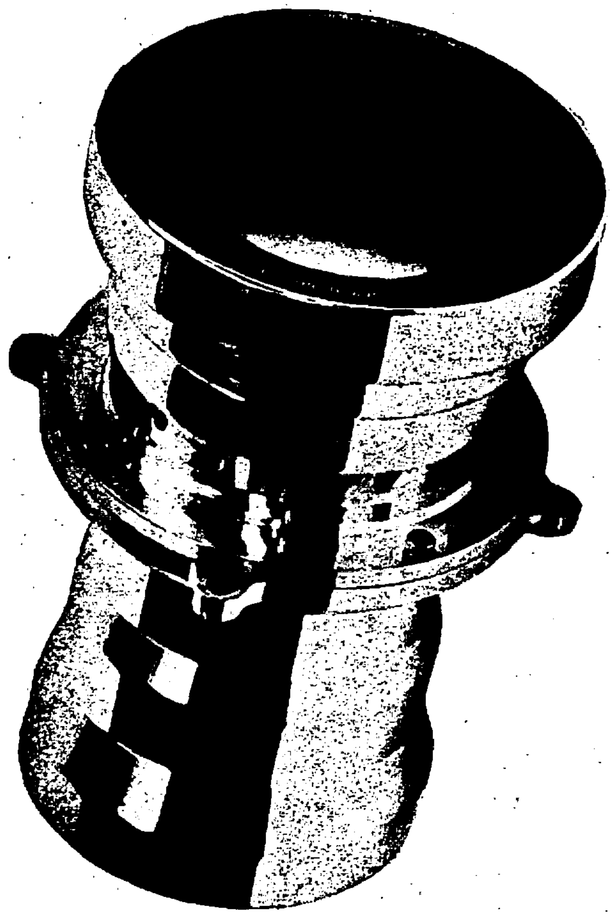

24-Inch Pacific Optical Lens

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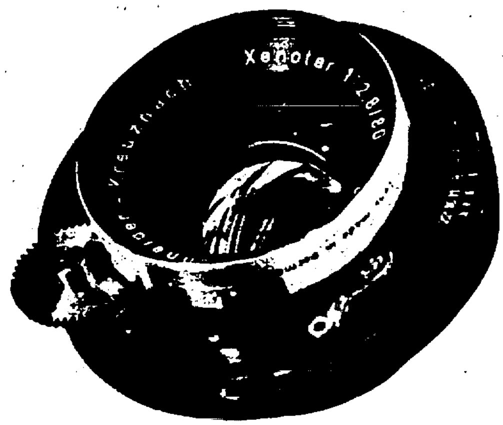


80-mm Schneider-Xenotar Lens



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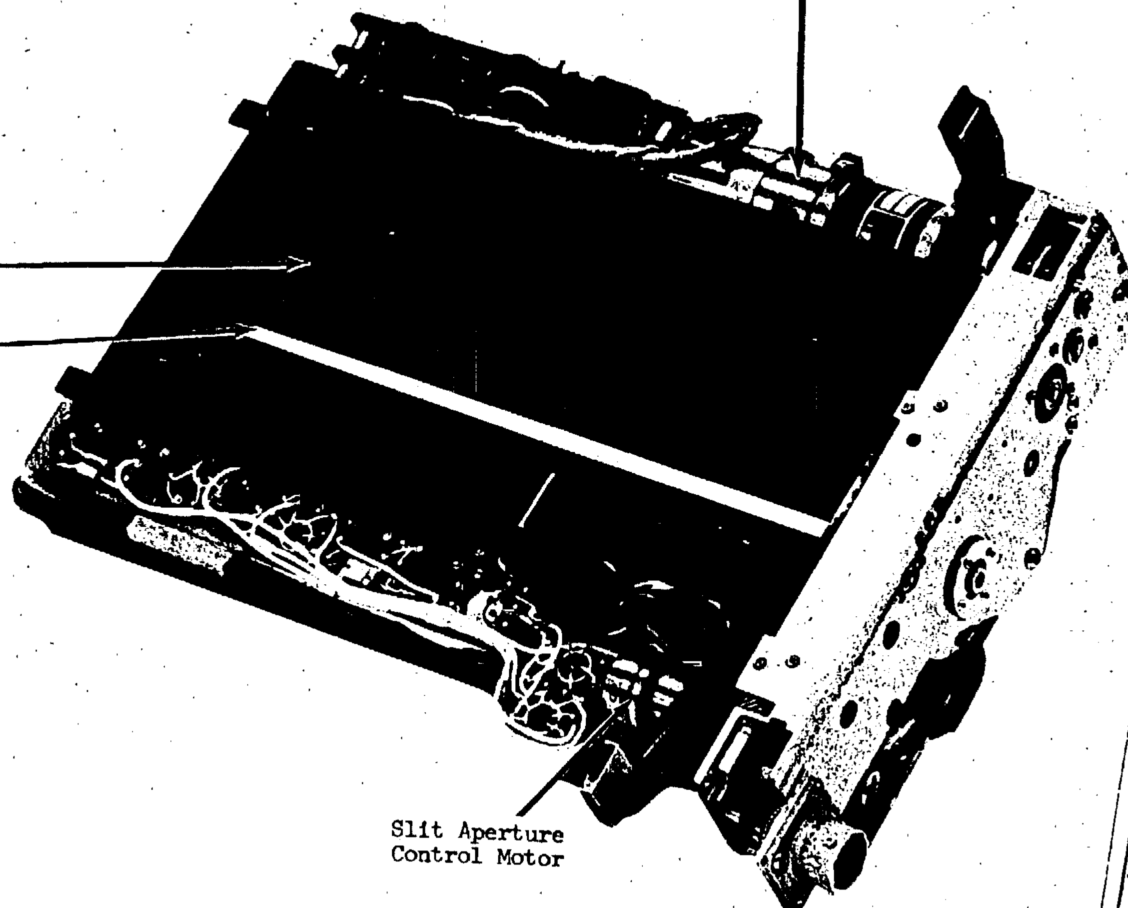
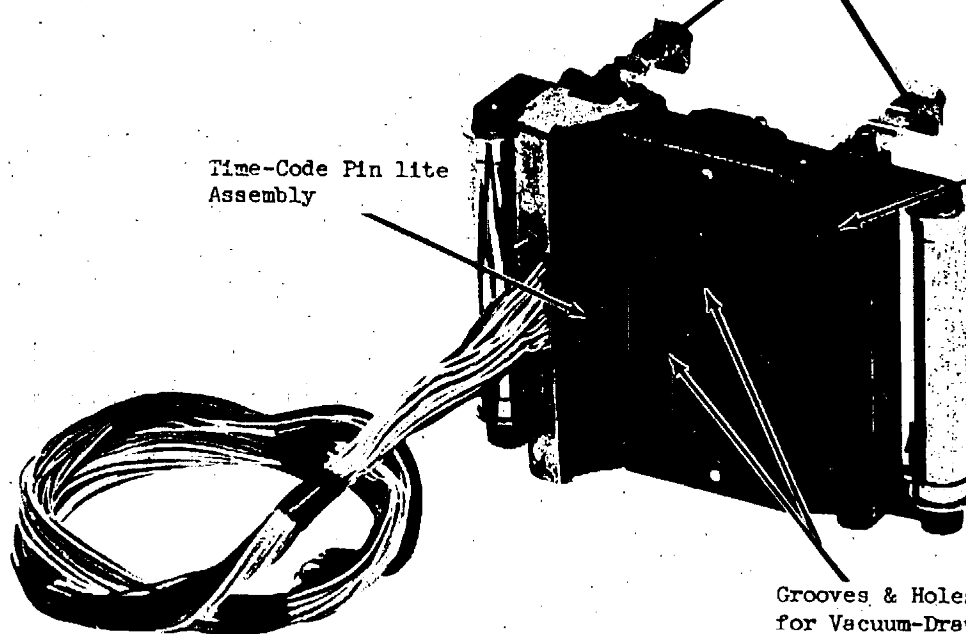



24-Inch Shutter Assembly, Showing Shutter urtains
in Mid-Travel

2-220


Platen Mounting Flexures (Provide Flexibility for IMC Travel)
Film Clamp Frame
Time-Code Pin lite Assembly
Grooves & Holes for Vacuum-Draw Film Flattening

80-mm Platen

The Processor/Dryer

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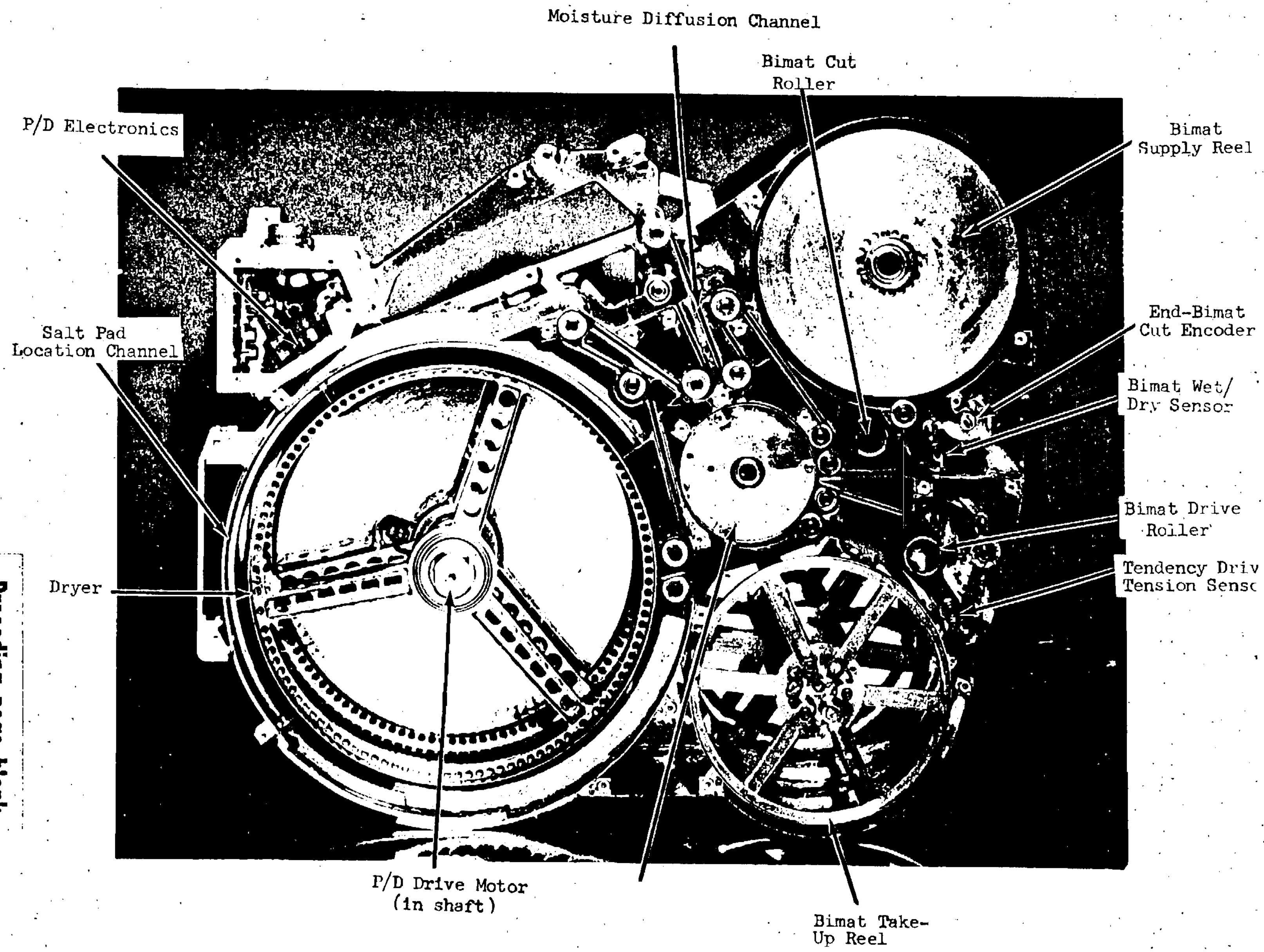




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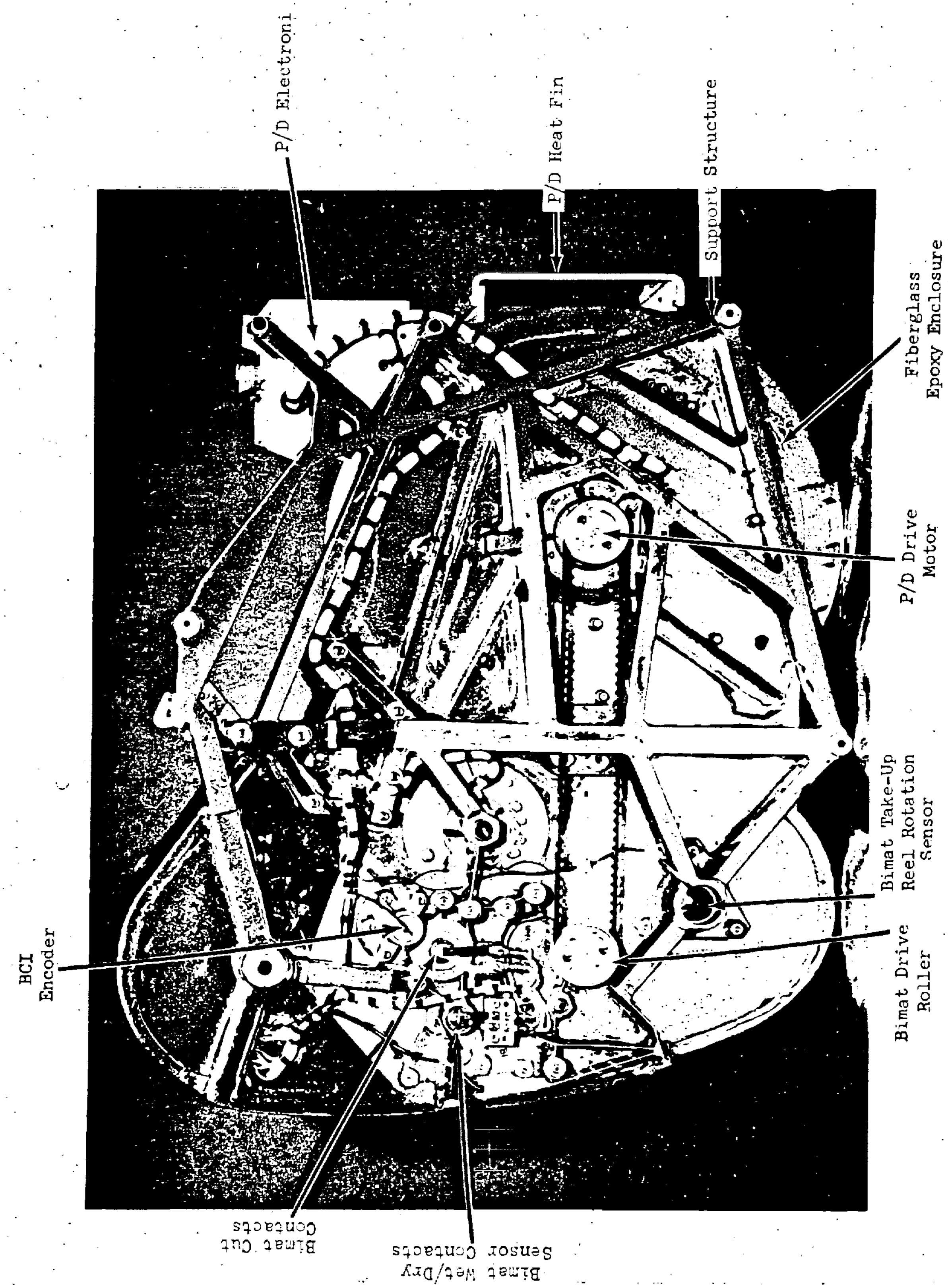
P/D Electroni
P/D Heat Fin
Support Structure
Fiberglass Epoxy Enclosure
P/D Drive Motor
Bimat Take-Up Reel Rotation Sensor
Bimat Drive Roller
BCI Encoder
Bimat Cut Contacts
Bimat Wet/Dry Sensor Contacts

[redacted]

The Read-out Group Breadboard

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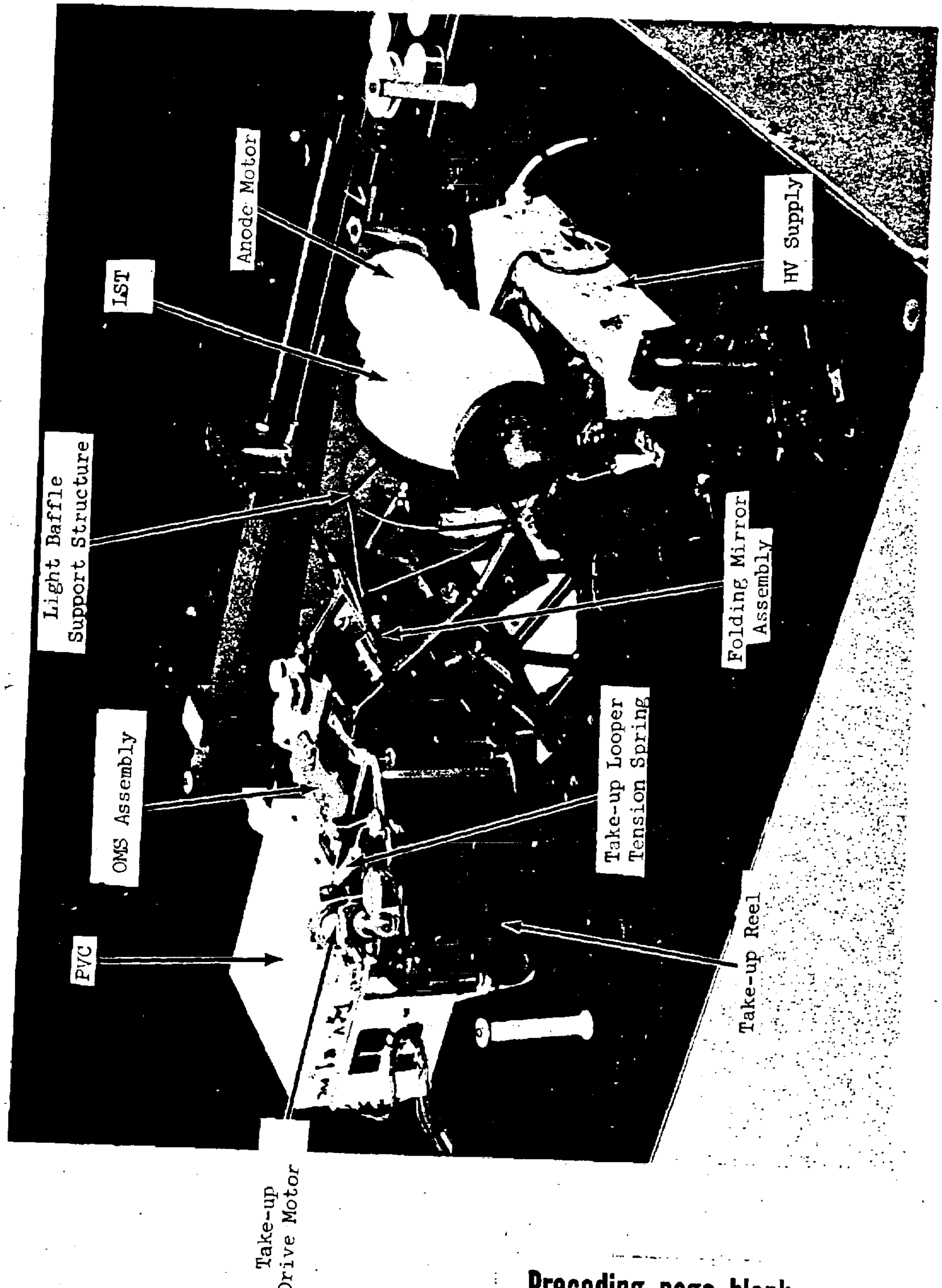


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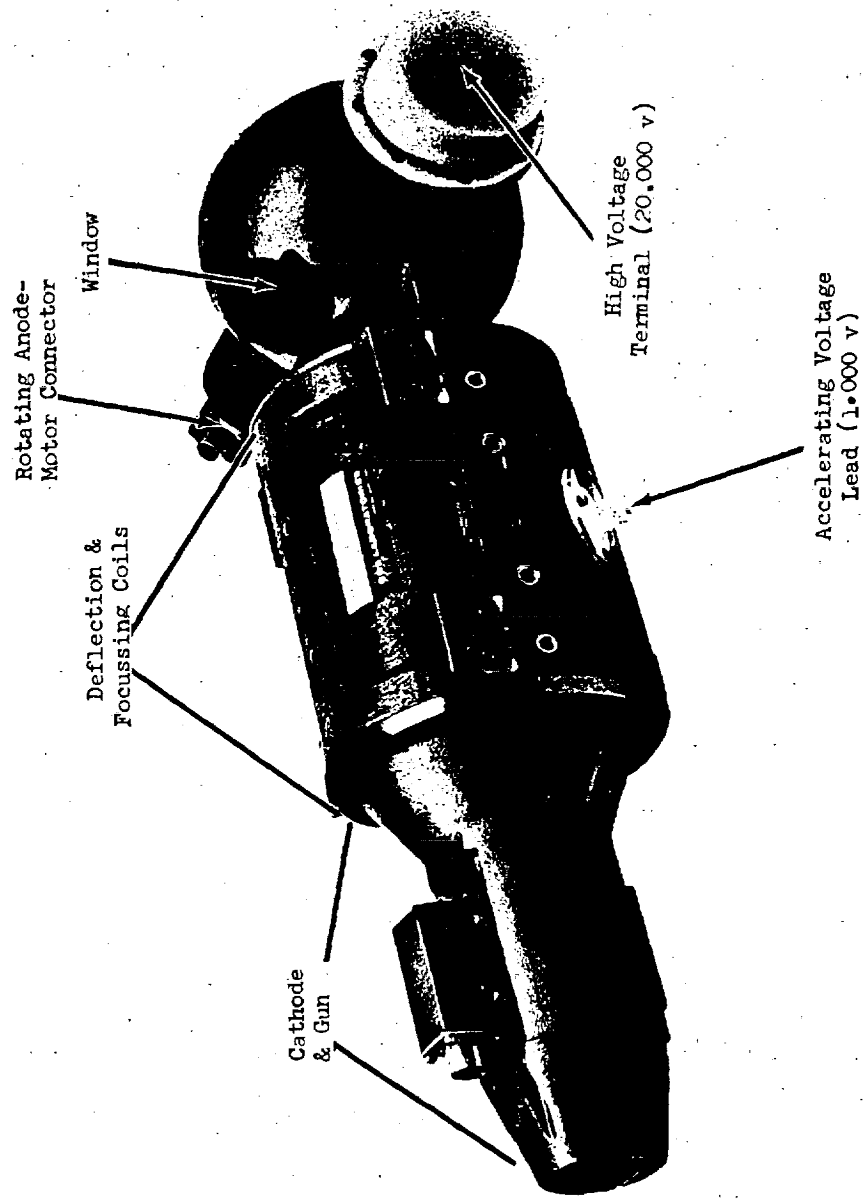


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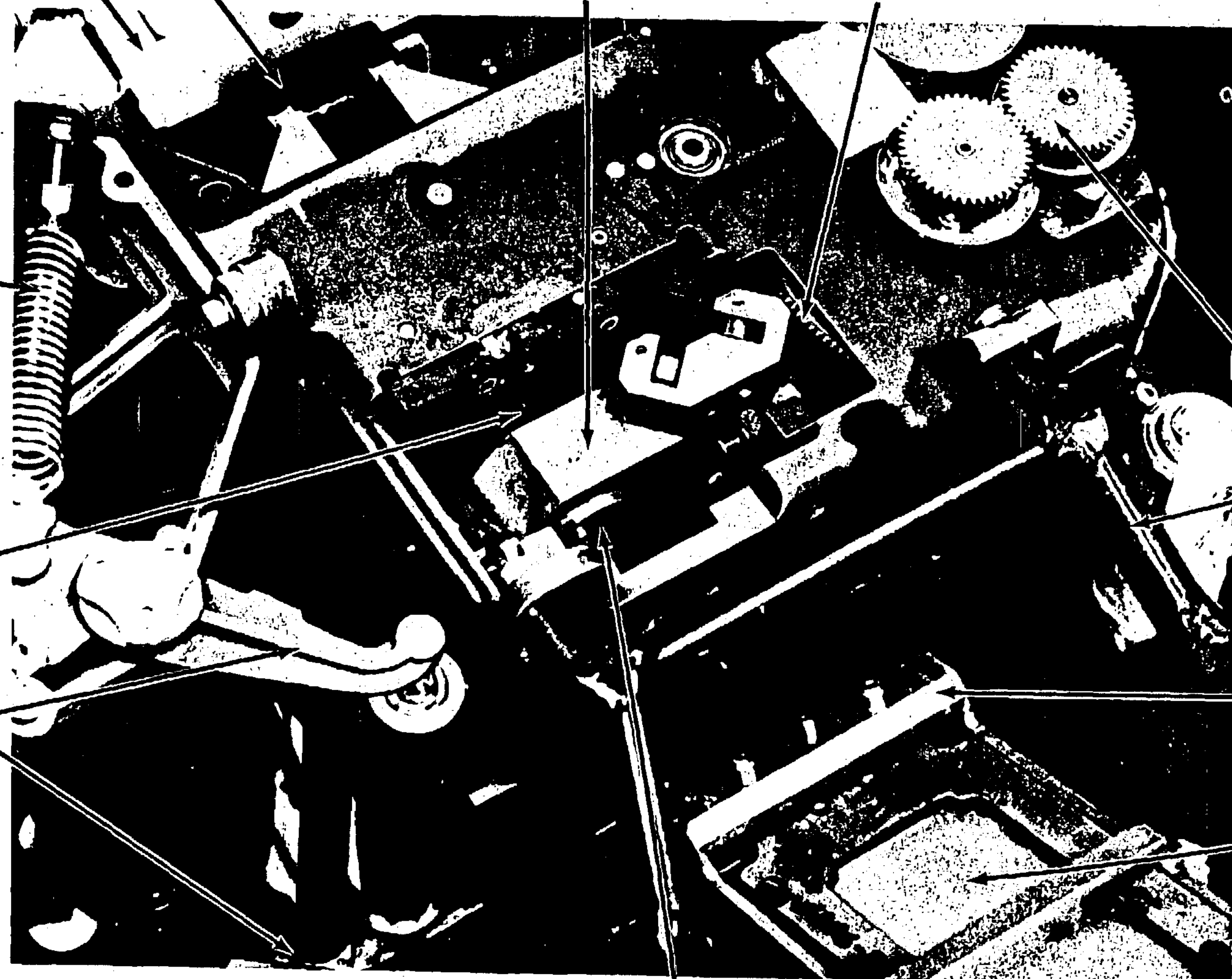
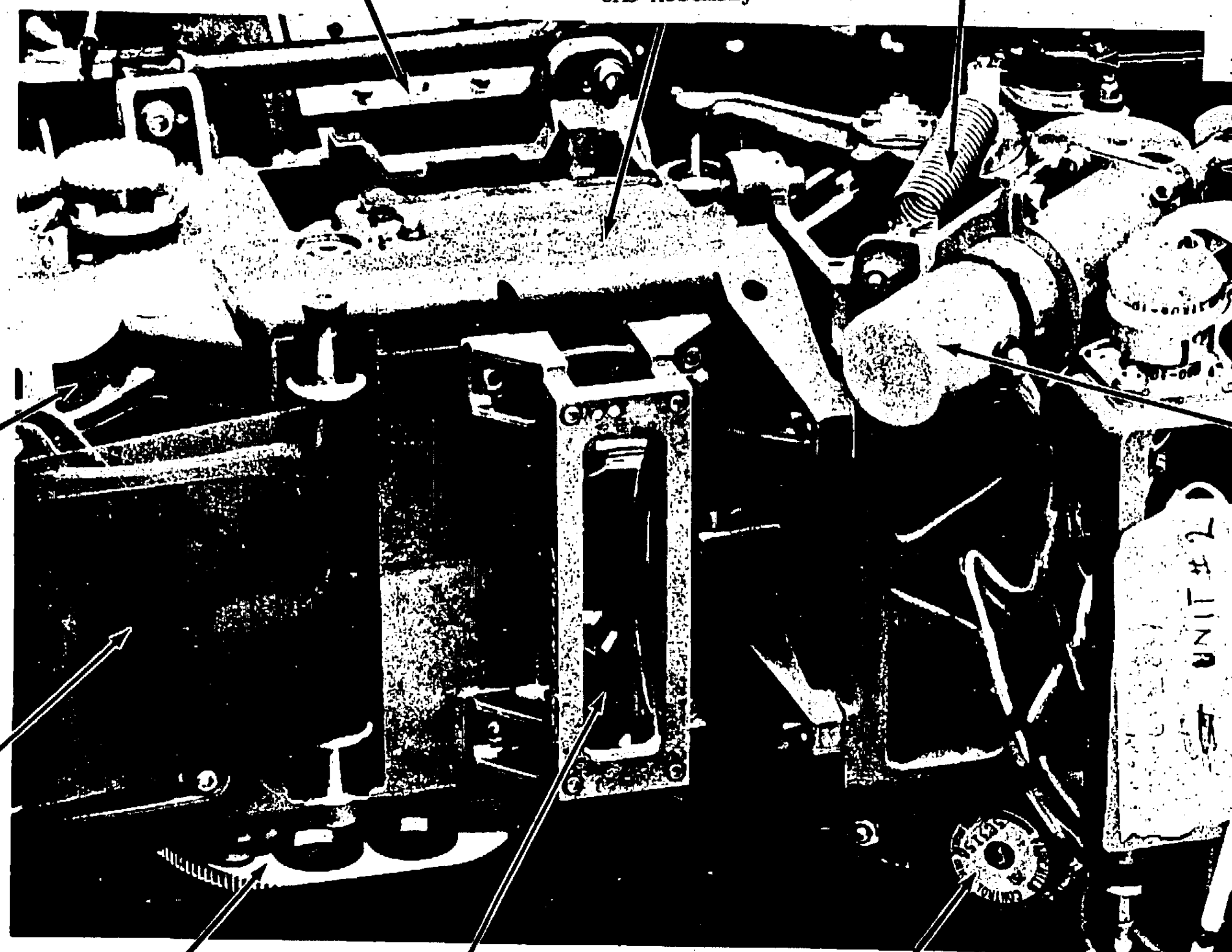

PVC in Position
Rubber Boot
OMS Lens Carriage
Drum Cam Drive Gear
SPS & FSS Encoder Drive gear
Read-out Truss Assembly
Folding Mirror Assembly
Folding Mirror
OMS Lens
Take-up Looper Pivot Arm
OMS Film Gate
Take-up Looper Tension Spring

[redacted]


Take-up Looper
Tension Spring
Folding Mirror Assembly
OMS Assembly
Take-up Looper Encoder
Worm Drive Gear
Take-up Drive Motor
OMS Drive Motor Output Gear
OMS Drive Motor (Behind Film)
OMS Film Advance Drive Gear
OMS Collecting Optics
Take-up Contents Pot
UNIT #2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# The Film Handling System Breadboard

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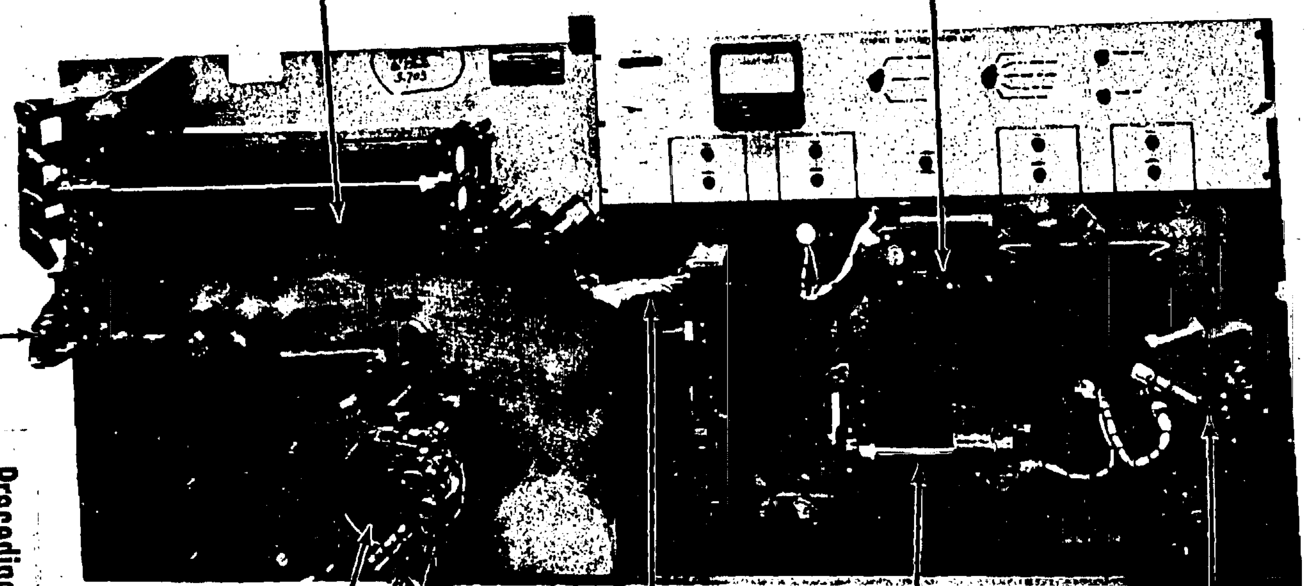


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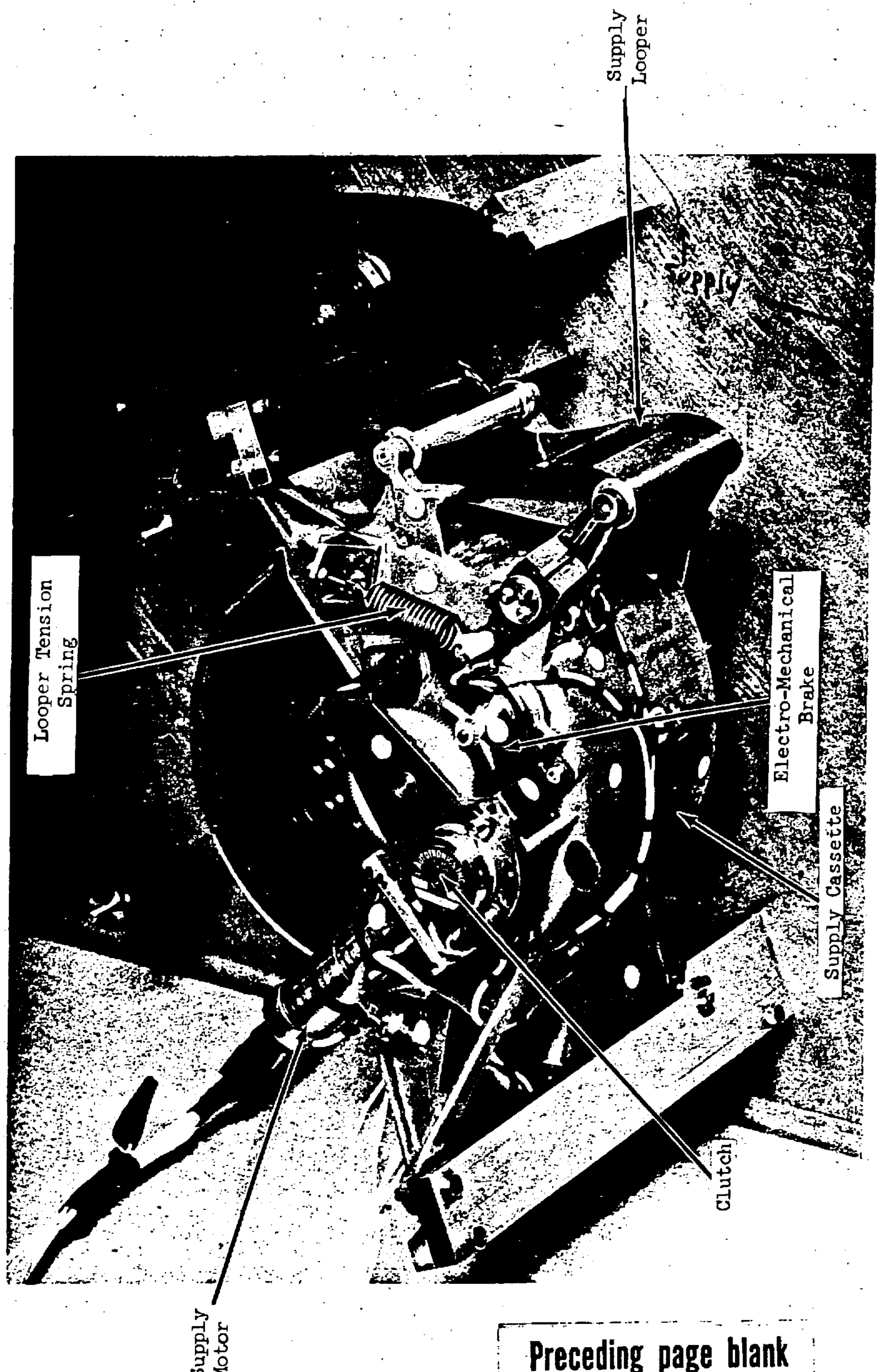


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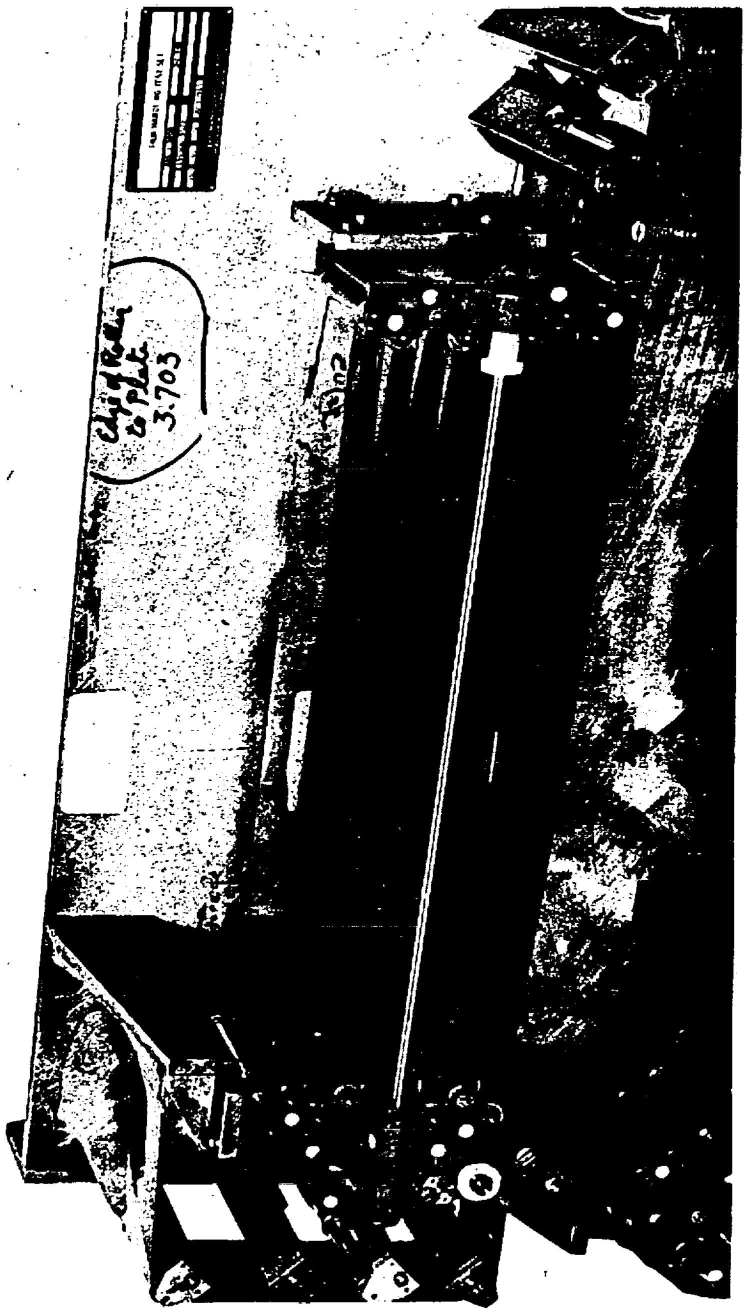


Camera Storage Looper

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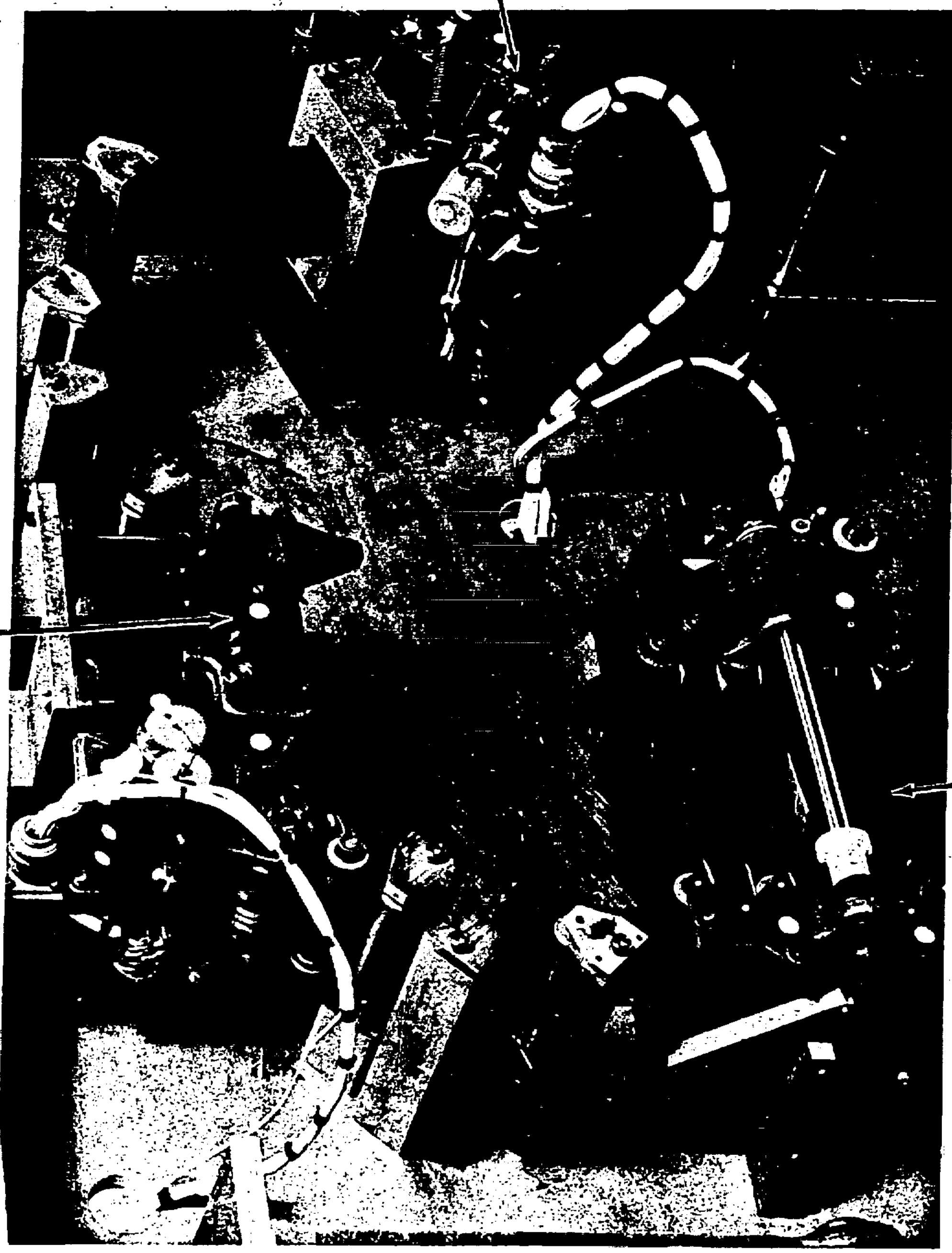


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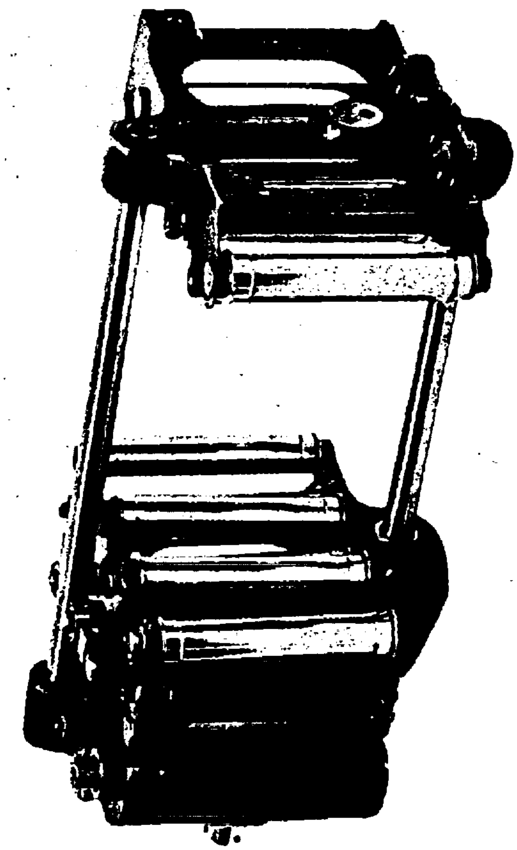

R/O Looper

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Nitrogen Make-up Assembly

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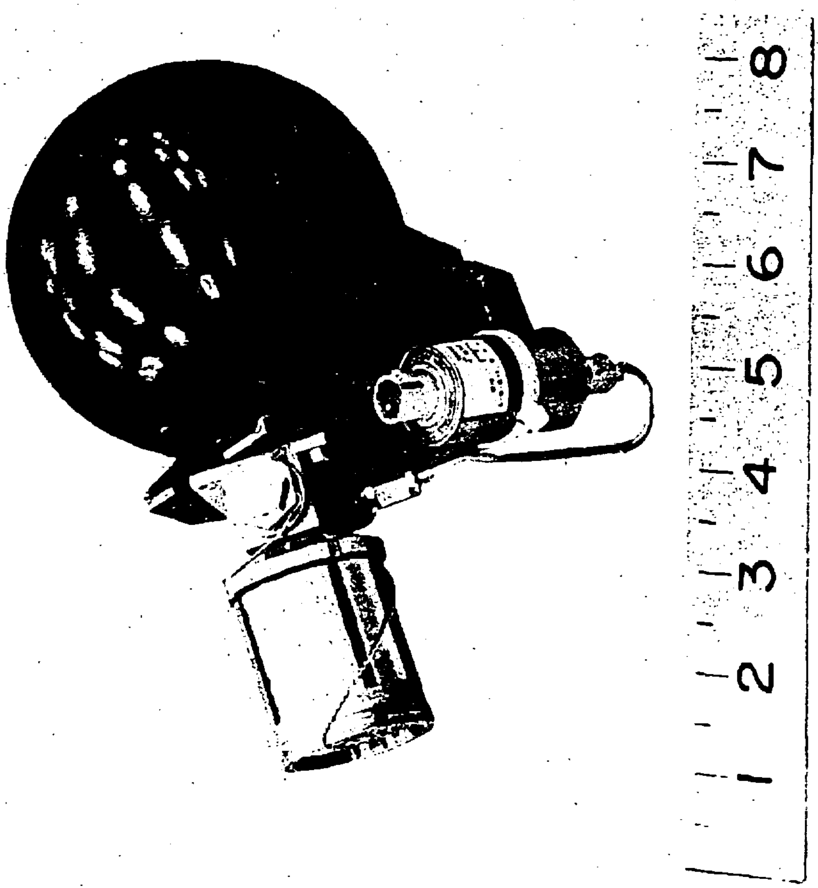


Nitrogen Make-up Assembly

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# SECTION 3
# COMMANDS

It is intended that this section provide a general description of the spacecraft command subsystem, the command generation procedure which takes place, and the sequence of events which occurs in command loading and execution. This section also contains listings of the word formats for PS commands.

## 3.1 OPERATION OF THE COMMAND SUBSYSTEM

Spacecraft commands originate at the SFOF. When a command sequence has been generated, the commands are transmitted to the deep space station (DSS) over a teletype line as command strings. The command string is composed of a predetermined number of command triplets, where each triplet is a single command word of 26 bits which is sent three times in succession. (The triplets are used to assist in command verification processes at the DSS). After a number of command checking and verification operations have taken place, the command sequence is transmitted to the spacecraft.

Commands are transmitted to the spacecraft by phase modulating a single command word of 26 bits on a 2116mc, S-band, rf carrier at the DSS. Note: the triplet format used in transmission from the SFOF to the DSS is not used here. At the spacecraft, the rf carrier is received by the low-gain antenna. The 26-bit command is extracted from the carrier in the command decoder where it is demodulated and stored temporarily. The command word is then re-transmitted to the DSS where it is checked for correctness. When correctness has been verified, an execute-signal is added to the rf carrier and sent to the spacecraft. When the command

decoder receives the execute-signal, it reads out the stored command and supplies it to the flight programmer for immediate execution (real-time commands) or for storage and later execution (stored-program commands).

Spacecraft commands are separated into two basic types:

a. Real-time commands - consist of one 26-bit word and produce a spacecraft response within 500 milliseconds after receipt of the command-execute signal by the spacecraft command decoder.

b. Stored-program commands - consist of 2 or more 26-bit words, one of which is a 26-bit time word. They are stored automatically in sequence in the programmer unless otherwise commanded. These commands are executed when the time word attached to the commands matches the output of a clock contained in the spacecraft. When the times match, the command is read out of the programmer and executed.

Verification of PS commands can also take place at the time of execution through use of the command verification telemetry. See Section 2, Table 2-2 for a list of the command-verification telemetry points.

The flight programmer provides spacecraft time, performs computations and comparisons, and controls 120 spacecraft functions. The unit is capable of controlling all spacecraft functions for extended periods without ground instruction, thus minimizing ground-to-spacecraft communications. Access to any word in the 128 word memory is possible from earth during flight and reprogramming of spacecraft events can be accomplished at any time the spacecraft is in view of a prime DSIF station. Execution of programmed events can be accomplished at any time during flight operations.

## 3.2 COMMAND FORMAT

The PS command word format is the same for both real time and stored commands. The bit formats are given below for the two PS command formats (one for photography and one for read-out) and for the 26-bit time label.

### 3.2.1 Time Word Format

| | | | |
|---|---|---|---|
| 26 | 25 .................6 | 5 | 4...1 |

| Bit Number | Function |
|---|---|
| 1 through 4 | Spacecraft address |
| 5 | Specifies RTC or SPC - always SPC for time word |
| 6 through 25 | Binary time code: 0.1 secs to 29 hrs 7 min 37.6 seconds |
| 26 | Parity: Generated on the ground, to result in an even number of binary ones in the word. |

The least significant bit (No. 1) is transmitted first from the DSS.

### 3.2.2 Command Word Format

| | | | | |
|---|---|---|---|---|
| 26 | 25...........11 | 10....6 | 5 | 4....1 |

| Bit Number | Function |
|---|---|
| 1 through 4 | Spacecraft address |
| 5 | True: RTC (Binary one)<br>False: SPC (binary zero) |

| Bit Number | Function |
|---|---|
| 6 through 10 | Operation code |
| 11 through 25 | Magnitude or function bits |
| 26 | Parity: generated on the ground, to result in an even number of ones in the word. |

Again, the least significant bit is transmitted first.

3.2.2.1 PS Command Word Format

a. Camera Command No. 1 - Camera Take Picture (CTP). To identify this command, the operation code bits are set as follows:

| | | | | | |
|---|---|---|---|---|---|
| Bit Number: | 6 | 7 | 8 | 9 | 10 |
| State: | 1 | 0 | 0 | 0 | 1 |

The function bits (11-25) are then determined as shown:

| Bit No. | Function | EKC Nomenclature |
|---|---|---|
| 11 | V/H ON | SPC-1 |
| 12 | Camera ON | SPC-2 |
| 13 | Camera shutter ADVANCE | RTC-7 |
| 14 | Frame count B or $\bar{B}$ | SPC 30 or 31 |
| 15 | Frame count A or $\bar{A}$ | SPC 28 or 29 |
| 16 | Slow or fast camera rate | SPC 27 or 26 |
| 17 | V/H OFF | SPC-4 |
| 18,19 & 20 | Cut bimat | RTC-8 |
| 23 | Camera thermal-door OPEN | Not EKC command |
| 24 | Camera thermal-door CLOSED | Not EKC command |
| 25 | Camera thermal-door-control OFF | Not EKC command |

As can be seen by the PS commands the purpose of this command is to operate the PS during photography and processing.

b. Camera Command No. 2 - Read-Out Camera (ROC)
To identify this command, the operational code bits are the following:

| | | | | | |
|---|---|---|---|---|---|
| Bit Number: | 6 | 7 | 8 | 9 | 10 |
| State: | 0 | 1 | 0 | 0 | 1 |

The function bits are then determined, as given:

| Bit No. | Function | EKC Nomenclature |
|---|---|---|
| 11 | Read Out electronics ON | SPC-3 |
| 13 | Read Out drive ON | RTC-5 |
| 14 | Read Out drive OFF | RTC-6 |
| 15 | Heater power OFF | RTC-9 |
| 16 | Heater power ON | RTC-9 |
| 17 | LST focus INCREASE | RTC-11 |
| 18 | LST focus DECREASE | RTC-12 |
| 19 | Photo video gain INCREASE | RTC-13 |
| 20 | Photo video gain DECREASE | RTC-14 |
| 21 | Wind forward | RTC-16 |
| 24 | Solar eclipse ON | SPC-18 |
| 25 | Solar eclipse OFF | SPC-19 |

Camera command No. 2 is thus used to operate the PS during photo read-out.

# SECTION 4
# VIDEO TRANSMISSION LINK

## 4.1 THE SYSTEM

The photographic information is scanned in the PS and converted to an electrical signal. From the PS, the electrical signal is passed through the modulation selector to the communications subsystem transmitter and then to the DSIF. At the DSIF, it is recorded on 35-mm film which is later used in the 9 1/2-inch reassembly printer at EKC Rochester to produce prints of reassembled frames.

### 4.1.1 The PS System (See paragraph 2.2.6 for a complete description of the read-out chain).

A line scan tube generates a spot, which moves at a constant velocity and is imaged on the film. The film density modulates the transmitted light intensity; this light is then converted to an electrical voltage (video signal) by a photomultiplier tube.

The video signal is an analog signal that varies between 0 (black) and 5 volts (white). A 0.9-volt sync pulse is added during the blanking time forming a composite video signal. The total scan time is 1250 microseconds (800 cps). The frequency components of the composite video signal are limited to a band from 1.5 cps to 230 kc.

### 4.1.2 The Communications Link

The video signal from the video amplifier in the PS is fed to the modulation selector and used to amplitude modulate a 310 kc signal which in turn is used to modulate the 2295 mc transponder output. A vestigial sideband

filter rolls-off frequencies above 230 kc on the 310 kc subcarrier. In addition, the 310 kc subcarrier is suppressed; however, a 38.75 kc signal (310 kc counted down by 8) is used as another low-level subcarrier for later multiplication by 8, to coherently reinsert the carrier at the DSIF. Each of these mechanisms (vestigal sideband, suppressed subcarrier) is used to improve the signal-to-noise (S/N) ratio.

The transponder output feeds a traveling wave tube (TWT) amplifier using a directional coupler. This, in turn, feeds a high-gain dish antenna for transmission to the DSIF. The frequency spectrum is shown in Figure 4-1 and the block diagram of the communications package in Figure 4-2. The latter includes all the control and telemetry points discussed in Section 5.

4.1.3 DSIF System

After demodulation of the 2295 mc signal, the composite video signal is recorded on magnetic tape while being optically recorded by the Ground Reconstruction System (GRS). This system is actually the inverse of the PS read-out system. The electrical composite-video signal modulates the light intensity of a spot, on a cathode ray tube. This spot is swept and scanned synchronously with the scan in the PS read-out group. The optical spot is imaged on 35-mm film which is advanced proportionally (and continuously) as the scanner in the read-out moves across the 70-mm film. The result is a 35-mm framelet. The width of the recorded framelet is 0.72 inches, which corresponds to a scanned width of 0.1 inch on the 70-mm SO-243 film in the PS. The length is magnified by the same ratio (7.2). The 35-mm framelets are positive images of the lunar surface.

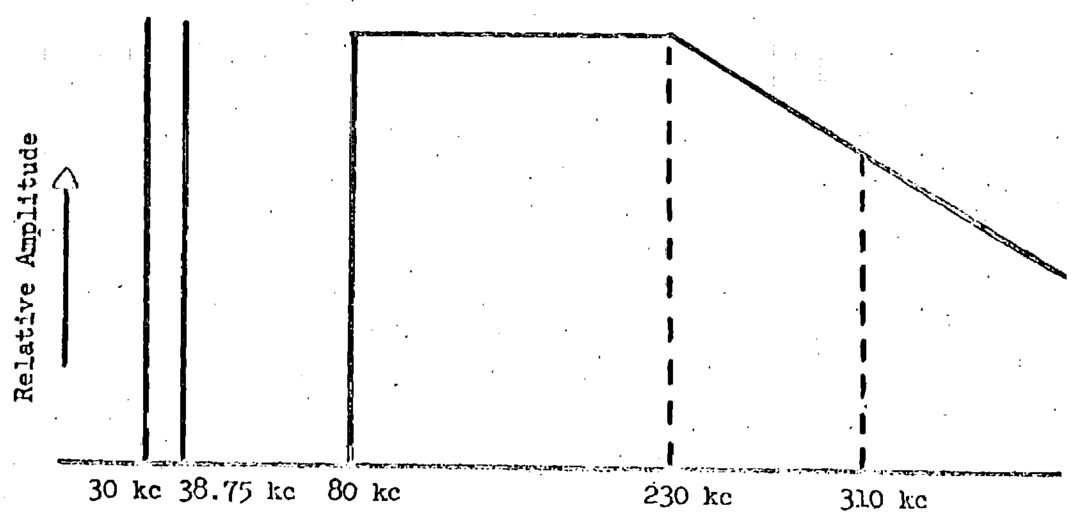



Figure 4-1. Frequency Spectrum

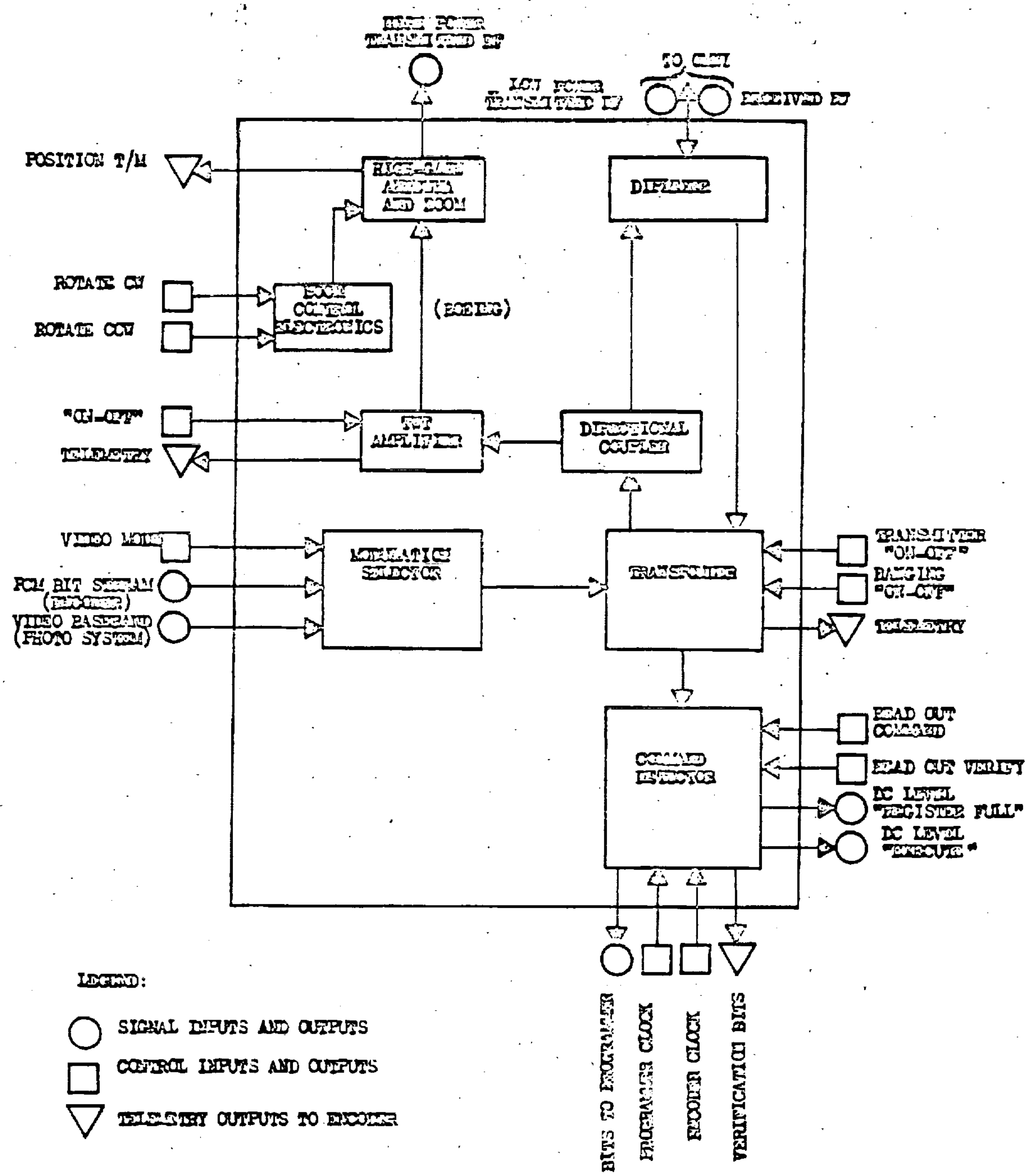



Figure 4-2. Communications Package Simplified Block Diagram

### 4.1.4 Reassembly

The framelets recorded by the GRS are placed side by side and printed together on 9 1/2-inch film. This reconstructed frame consists of 14 framelets. The magnification factor in the reassembly operation is 0.8927 with respect to the 35-mm film. The resulting image has the 14 framelets printed together across a 9-inch width on the reconstructed frame. As a result of the film width limitations, neither a high nor a moderate resolution frame can be reconstructed on a single 9 1/2-inch frame. The reassembled frame is a photographic negative. The reassembly process takes place using the reassembly printer at EKC-Rochester.

In the process of reconstructing an entire picture (which requires more than one 9 1/2-inch frame), the last two framelets of one frame are printed as the first two of the next frame, for registration purposes. Therefore three 9 1/2-inch frames are required to reconstruct the 80-mm frame, to be sure of covering the entire frame. Similarily, the 8.62-inch-long 24-inch camera frame, requires eight 9 1/2-inch frames to cover its 86.2 framelets. The total magnification factor of the combined GRS reassembly operation is 7.20 (0.893) = 6.43, with respect to the original 70-mm film in the PPS.

The reassembly printer also adds a block of titling data to each of the reassembled photographs. The titling information includes data on the Flight Number, coordinates of photography, sun elevation angle, etc.

# SECTION 5
# FUNCTION TELEMETRY

## 5.1 DESCRIPTION OF TELEMETRY LINK

The PS telemetry is divided into analog and digital telemetry. Both types are present at the PS telemetry interface and are connected to the pulse code modulation (PCM) encoder for processing prior to delivery to the communication subsystem. Both analog and digital telemetry are coded in non-return to zero (NRZ) binary form and are then transmitted to the DSIF.

The communications channel is such that all the telemetry existing in parallel at the PS must be sent serially. It is therefore sampled at a given rate by commutator and multiplexer within the PCM encoder. Both digital and analog telemetry points are sampled at the same rate (once every 24 seconds). The analog signals, after being commutated (sampled), are converted to a nine-bit digital code, via an analog to digital (A/D) converter. Eight bits are used to determine to which of 256 levels the analog signal corresponds within the 5-volt range; the ninth bit is the complement of the eighth. The digital telemetry remains in its original digital form.

The digital coded analog telemetry and the digital telemetry are then arranged into frames, where each frame contains all the spacecraft telemetry points, in digital form, at a 50 bit per second rate. Each frame contains 128 words of 9 bits each. Three words are used to contain the separate digital information. This code stream, in a non-return to zero format, is fed to the modulation selector. When video data is not being transmitted, the digital bit-stream is transmitted from the low gain (-3 db) omni-directional antenna.

When a video signal is being transmitted, the digital-bit-stream is transmitted, along with the video data, from the high gain (+23 db) disk antenna.

## 5.2 TELEMETRY POINTS

Tables 5-1 and 5-2 contain lists of the flight-and ground test-instrumentation points provided for the PS. Figures 5-1 through 5-10 are sketches of the circuits for each type of telemetry point in the PS (these circuits are numbered -- the circuit number for each point is included in Tables 5-1 and 5-2).

Table 5-1
Flight Telemetry Points
The following items are supplied by the Photosubsystem to the PCM encoder:

| Designation TBC | EKC | Title | Range | Digital | Analog | Accuracy in Percent* | Bits | Typical Circuit No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| PB01 | FTL-1 | Take-up contents | 0-260 ft. | | X | 5.1 | 8 | 1 | See note 3 |
| PB02 | FTL-2 | Camera looper contents | 0-23.2 ft. | | X | 5.1 | 8 | 1 | See note 3 |
| PB03 | FTL-3 | Readout looper contents | 0-55 in. | | X | 5.1 | 8 | 1 | See note 3 |
| PR01 | CTL-5 | V/H ratio | 0-.05 $sec^{-1}$ | | X | 2 to 4 | 8 | 2 | See ATR for calibration (accuracy varies with V/H ratio) |
| PB04 | CTL-6 | Shutter operations | 0-31 | X | | NA | 5 | 3 | Counts backwards (31-0) |
| PB05 | CTL-7 | Platen operations | 0-31 | X | | NA | 5 | 3 | Counts backwards (31-0) |
| PC01 | CTL-8 | SPC-1, SPC-4 CV** | COS*** | X | | NA | 1 | 3 | |
| PC02 | CTL-9 | SPC-2 CV | COS | X | | NA | 1 | 3 | |
| PC03 | CTL-10 | Camera program setting | 0-7 | X | | NA | 3 | 3 | See code in Sec.2.3 |
| PC04 | CTL-11 | Camera shutter setting | 0-3 | X | | NA | 2 | 3 | See code in Sec.2.3 |
| PT01 | CTL-12 | V/H temperature | 40-140°F | | X | 5.1 | 8 | 4 | See note 4 |
| PT02 | CTL-13 | Camera temperature | 40-100°F | | X | 5.1 | 8 | 4 | See note 4 |
| PT03 | CTL-14 | Window temperature | 40-100°F | | X | 5.1 | 8 | 4 | See note 4 |
| PC15 | CTL-15 | RTC-7, SPC-26, SPC-27 CV | COS | X | | NA | 1 | 3 | |
| PC16 | CTL-16 | SPC-18, SPC-19 CV | COS | X | | NA | 1 | 3 | |
| PC07 | PTL-18 | Bimat clear | Not clear/ clear | X | | NA | 1 | 3 | True state: Logic, zero (low); that is, sensor goes from 1 to 0 when Bimat has been cleared. |

* See note 5 at end of table.
** CV means Command Verification
*** COS means Change of State

TABLE 5-1 (Continued)

| Designation TBC | EKC | Title | Range | Digital | Analog | Accuracy in Percent | Bits | Typical Circuit No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| PC08 | PTL-19 | Bimat take-up | COS | X | | NA | 1 | 3 | Reel rotation sensor |
| PT04 | PTL-20 | Processor temperature | 40-100°F | | X | 5.1 | 8 | 4 | See note 4 |
| PT05 | PTL-21 | Dryer temperature | 40-140°F | | X | 5.1 | 8 | 4 | See note 4 |
| PC09 | PTL-22 | RTC-8 CV | COS | X | | NA | 1 | 3 | |
| PE01 | VTL-23 | +10v converter output | 0-11 v.d.c. | | X | 2.2 | 8 | 5 | Linear 0-5vdc |
| PE03 | RTL-24 | LST cathode current | 4.5-23.9 μa | | X | 10.0 | 8 | 6 | Linear 0-5vdc |
| PE06 | RTL-25 | PM voltage | .05-2 k.v. | | X | 1.7 | 8 | 7 | Not calibrated below 1 kv |
| PE05 | RTL-26 | High voltage supply | 0-22.7 k.v. | | X | 10.0 | 8 | 8 | Linear 0-5v |
| PE04 | RTL-27 | Peak video output | 0-5 v.d.c. | | X | 5.1 | 8 | 9 | Nominal 6 sec decay time |
| PC10 | RTL-28 | SPC-3, RTC-16 CV | COS | X | | NA | 1 | 3 | |
| PC11 | RTL-29 | RTC-5, RTC-6 CV | COS | X | | NA | 1 | 3 | |
| PC12 | RTL-31 | RTC-11, RTC-12 RTC-13, RTC-14 CV | COS | X | | NA | 1 | 3 | |
| PT06 | RTL-32 | Read-out and fin temperature | 30-130°F | | X | 5.1 | 8 | 4 | See note 4 |
| PP01 | ETL-33 | PS pressure | 0-18 Psia | | X | 5.1 | 8 | 1 | See calibration curve supplied with transducer |
| PH01 | ETL-34 | PS humidity lower | 30-70% | | X | 10.0 | 8 | 10 | See 2.12 of 1200-141 |
| PH02 | ETL-35 | PS humidity upper | 30-70% | | X | 10.0 | 8 | 10 | See 2.12 of 1200-141 |

TABLE 5-1 (Continued)

| Designation TBC | EKC | Title | Range | Digital | Analog | Accuracy in Percent | Bits | Typical Circuit No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| PT07 | ETL-36 | PS environment temperature, lower | 30-130 F | | X | 5.1 | 8 | 4 | See note 4 |
| PT08 | ETL-37 | PS environment temperature, upper | 40-140 F | | X | 5.1 | 8 | 4 | See note 4 |
| PT09 | ETL-38 | Upper shell temperature | 40-100 F | | X | 5.1 | 8 | 4 | See note 4 |
| PP02 | ETL-39 | Pressure, nitrogen bottle | 0-3500 psia | | X | 5.1 | 8 | 1 | See calibration curve supplied with transducer |
| PC-20 | ETL-40 | RTC-9 CV | Not inhibited/ inhibited | | | NA | 1 | 3 | True state: Logic zero (low); i.e., heaters inhibited when low. |

Notes:

1. CV means Command Verification
2. COS means Change of State
3. Telemetry points do not necessarily have zero-volt intercepts at the lower limit and 5-volt intercepts at the upper limit, nor are they linear between intercepts. See Instrumentation Output Calibration Procedure (1200-141) for typical curves and the appropriate PS data package for actual curves (contained in Boeing TLM calibration book for each unit).
4. Temperature items are each separately calibrated at one point. The other temperatures are then known by shifting a reference calibration curve to that calibrated point. See 1200-141 for reference curves.
5. Sensor accuracy given in the table reflects all error-producing steps including:
   a. Sensor calibration
   b. A/D conversion
   c. Data link noise

Table 5-2

Hard-Line Telemetry Points

The following items are supplied by the Photosubsystem to a test connector J4 (P155) which is only available during ground testing:

| Designation | Title | Digital | Analog | Typical Circuit | Remarks |
|---|---|---|---|---|---|
| HTL-1 | Shutter action | X | | 3 | Least significant bit of CTL-6 |
| HTL-2 | Platen motion | X | | 3 | Least significant bit of CTL-7 |
| HTL-3 | Dry bimat indication | X | | 11 | Resistance measurement |
| HTL-4 | Composite video | | X | 12 | X10 Attenuation of composite video output |
| HTL-5 | Bimat supply temperature | | X | 13 | |
| HTL-6 | PS power line voltage | | X | 5 | Actual voltage isolated by resistor |
| HTL-7 | +10v converter output | | X | 5 | Actual voltage isolated by resistor |
| HTL-8 | +20v converter output | | X | 5 | Actual voltage isolated by resistor |
| HTL-9 | PS power line current | | X | 14 | $I_{PS} = 100V_o$ where $V_o$ is the output voltage |
| HLC-2 | Focus test command | X | | - | Inhibits camera film advance after exposure |
| HLC-3 | V/H override command | X | | 15 | Requires value of IMC to be externally supplied |

TABLE 5-2 (Continued)

| Designation | Title | Digital | Analog | Typical Circuit | Remarks |
|---|---|---|---|---|---|
| HLC-4 | Programmed IMC | | X | 15 | Externally supplied value of IMC |
| TPL-1 | -10v converter output | | X | 5 | Actual voltage isolated by resistor |
| TPL-2 | +6.5v converter output | | X | 5 | Actual voltage isolated by resistor |
| TPL-3 | -6.5v converter output | | X | 5 | Actual voltage isolated by resistor |
| TPL-4 | -20v converter output | | X | 5 | Actual voltage isolated by resistor |
| TPL-5 | +6.3v converter output | | X | 5 | Actual voltage isolated by resistor |
| TPL-6 | Sync output | | X | 16 | Derived from composite video |
| TPL-7 | Reference frequency output | X | | 3 | 800 cps |
| TPL-8 | Solar eclipse memory | X | | 3 | CCP internal state |
| TPL-9 | Wind forward memory | X | | 3 | CCP internal state |
| TPL-10 | Camera ON memory | X | | 3 | CCP internal state |
| TPL-11 | V/H Tachometer generator | | X | 17 | More accurate than CTL-5 |

1.

2.

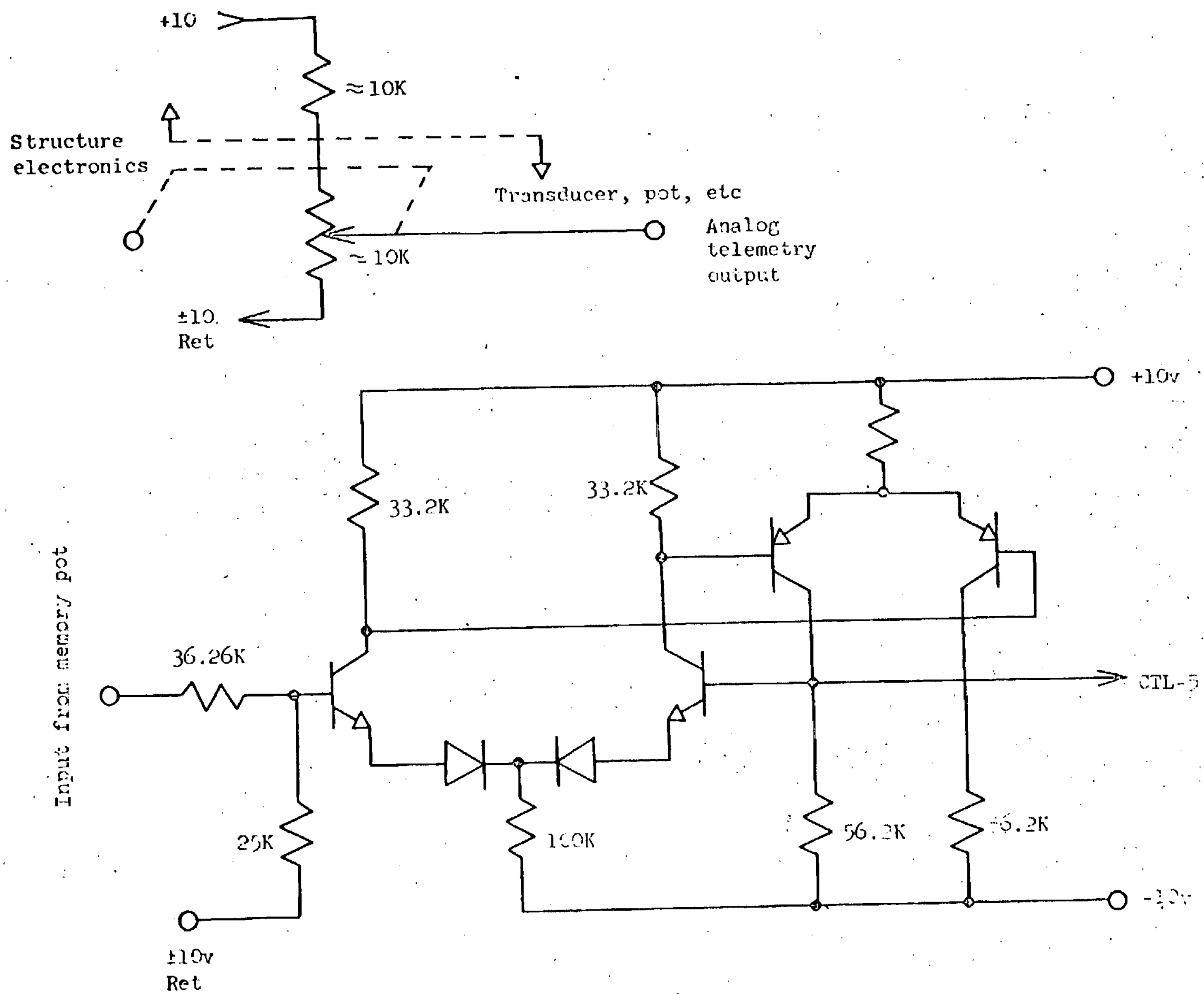
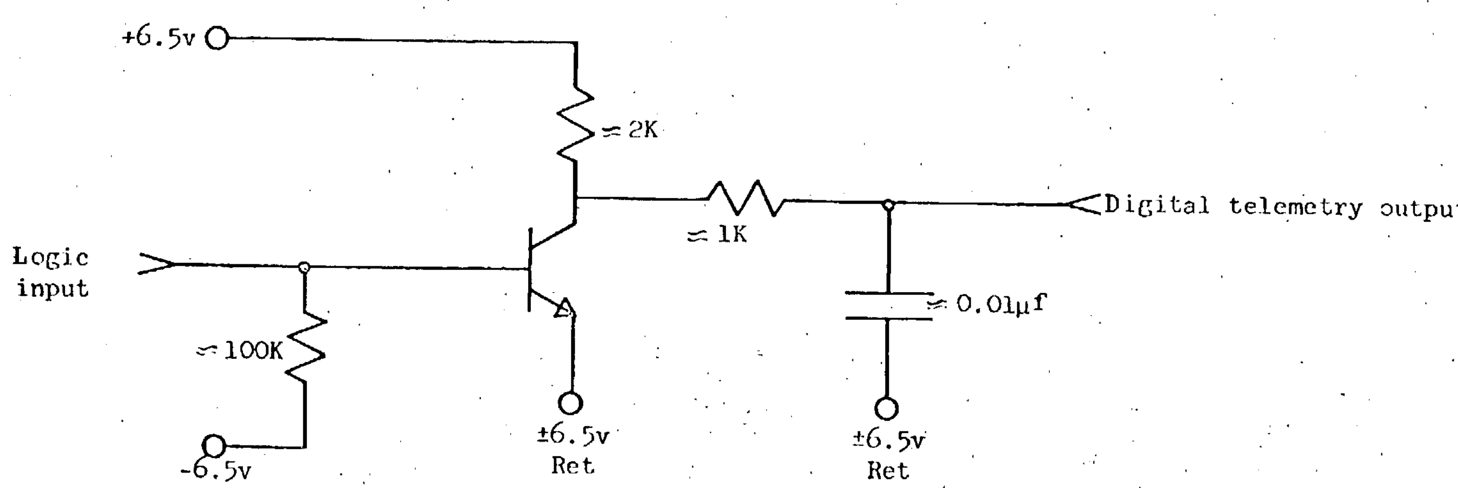
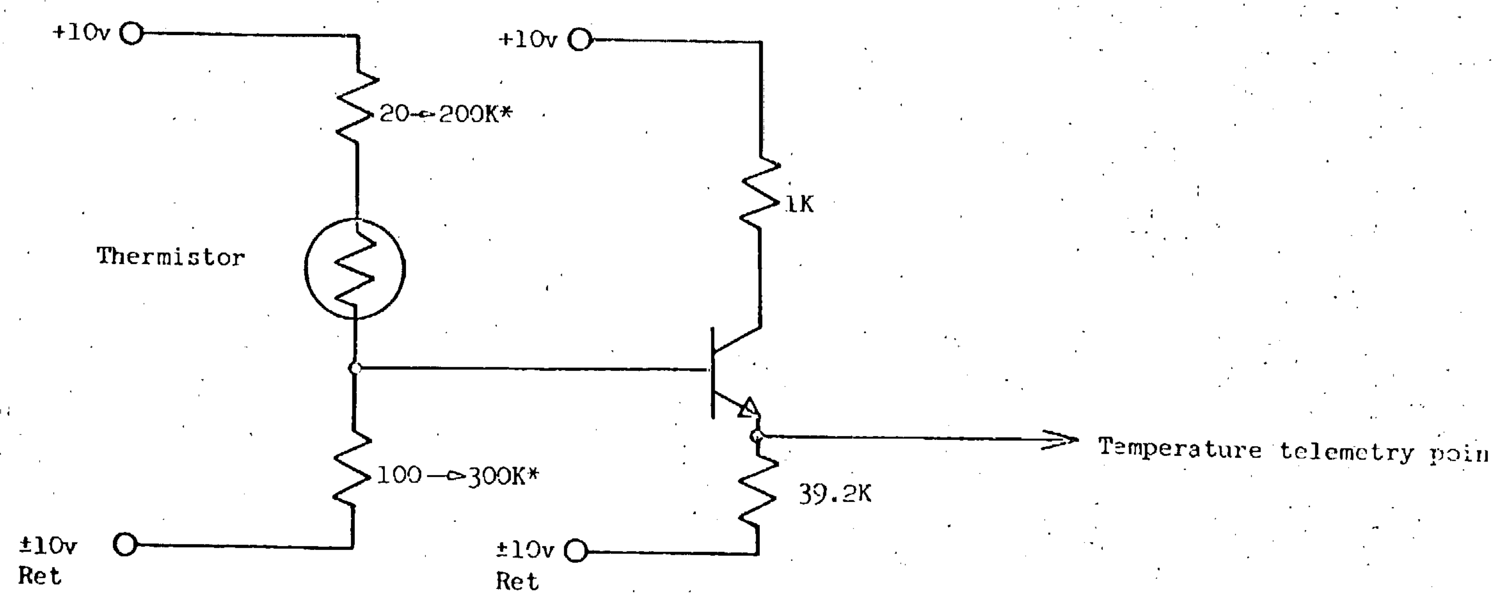



Figure 5-1. Typical Circuits, 1 and 2

3.




4.




*Exact value depends upon the thermistor.

Figure 5-2. Typical Circuits, 3 and 4

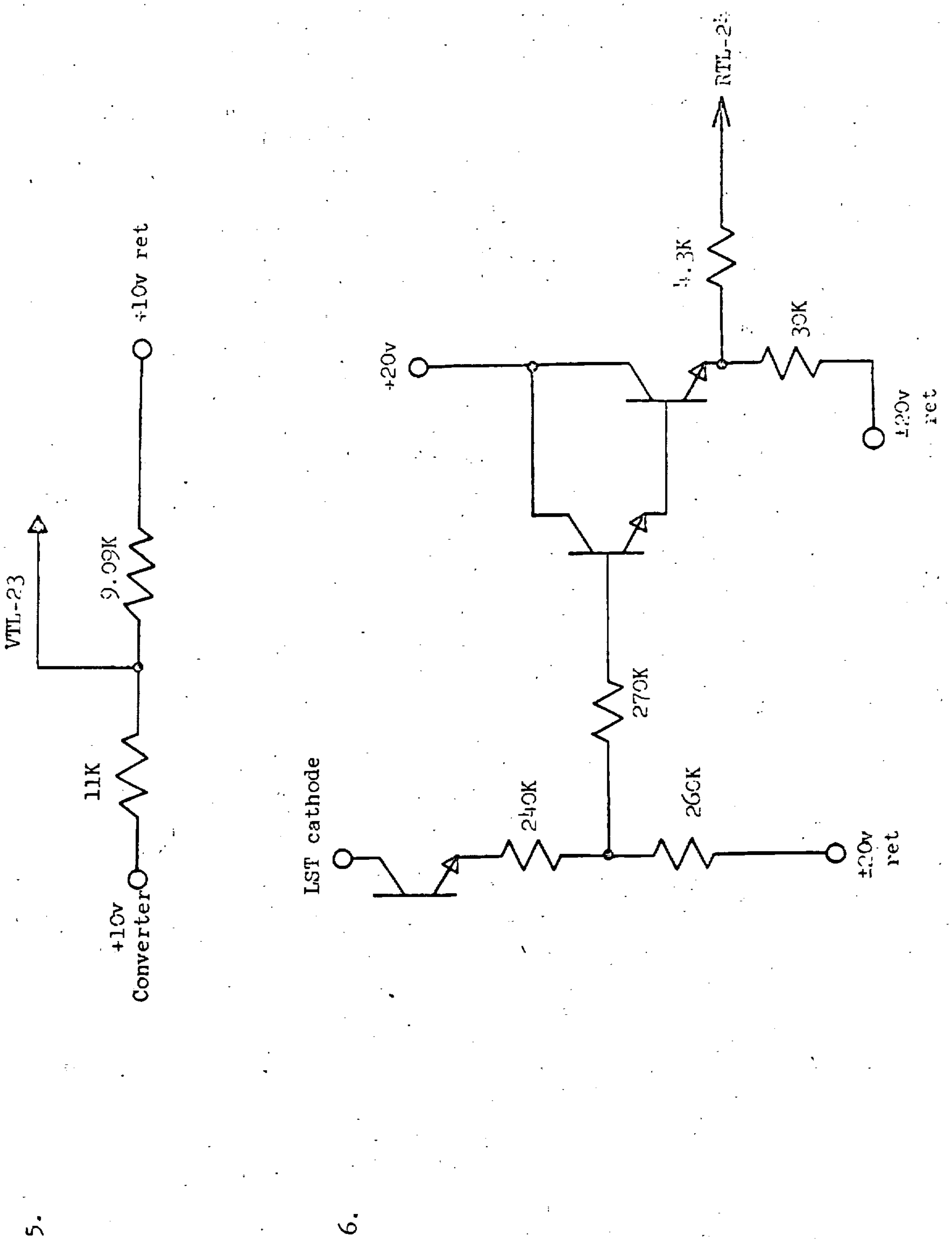



Figure 5-3. Typical Circuits, 5 and 6

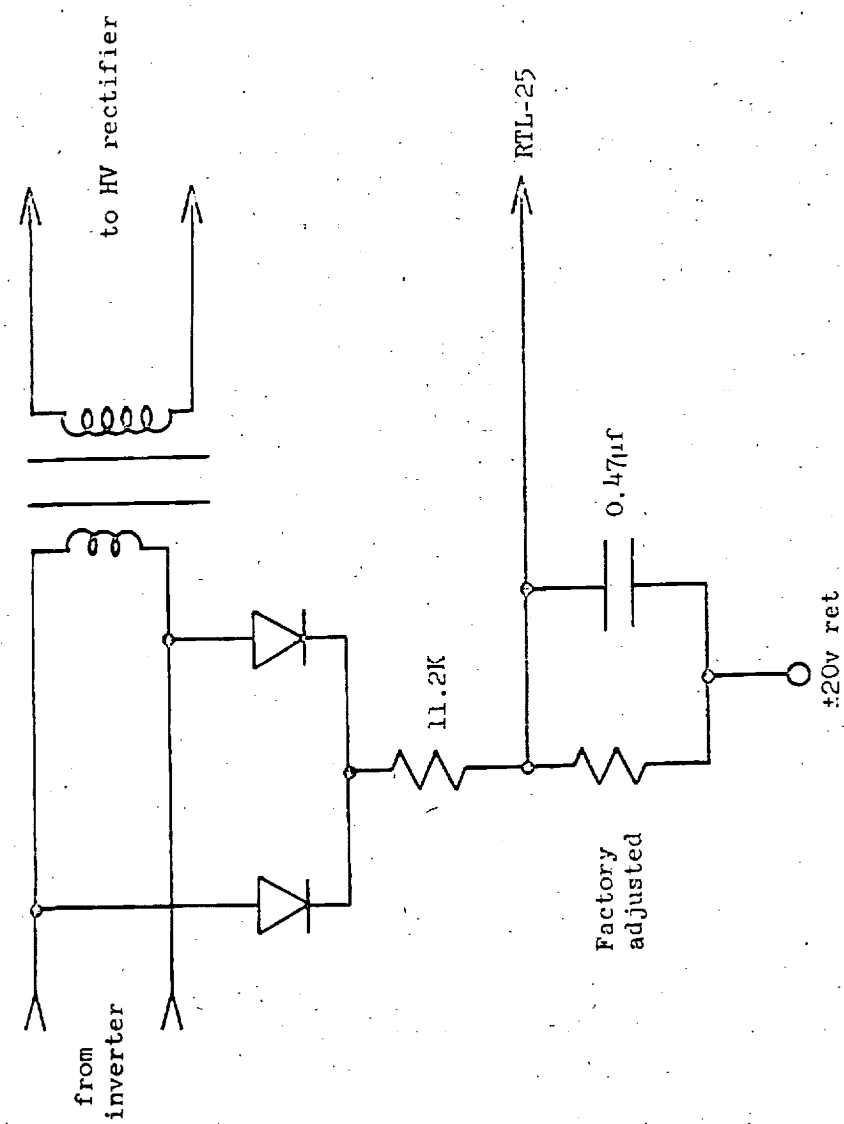



Figure 5-4. Typical Circuit,7

8.

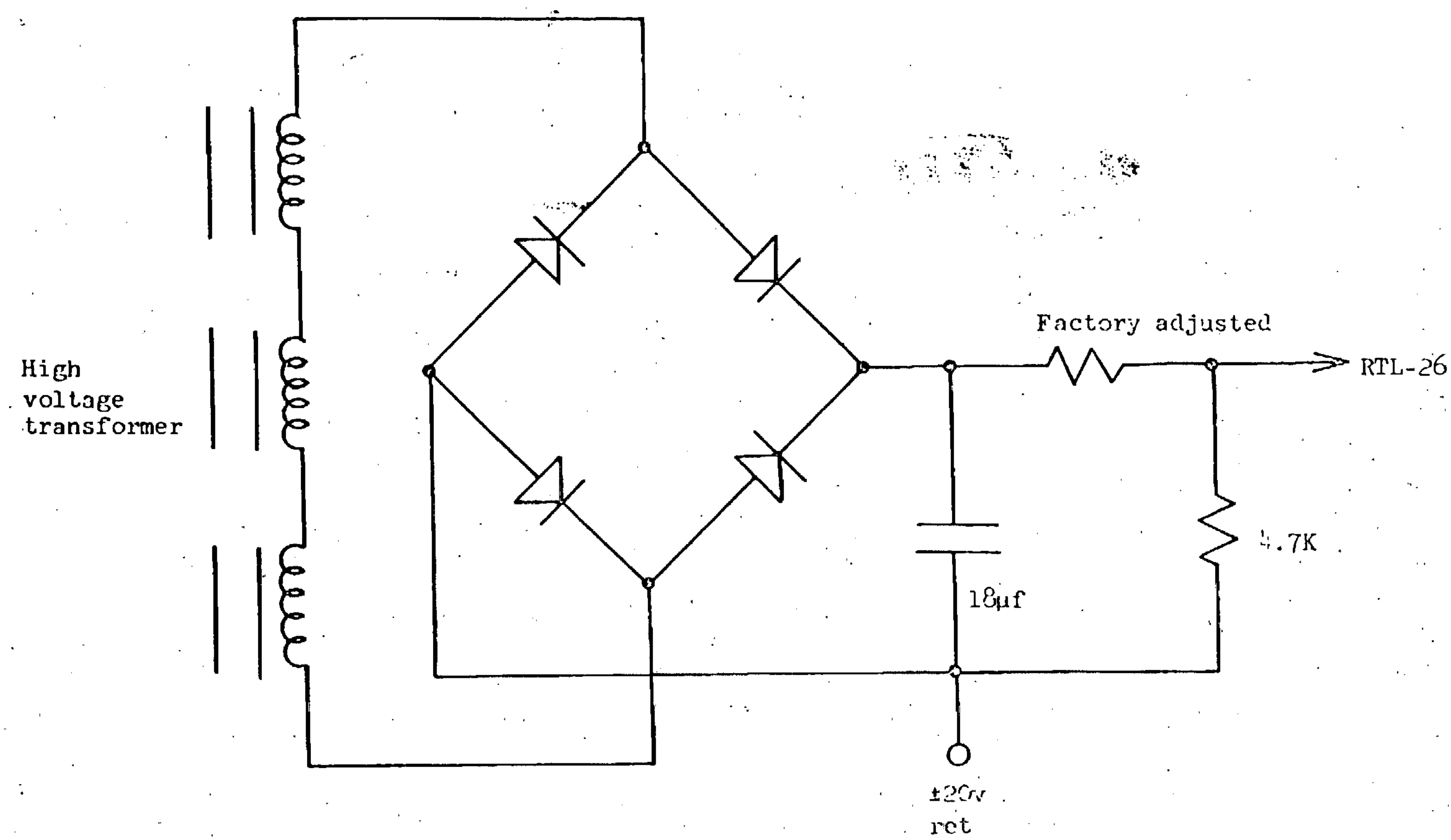
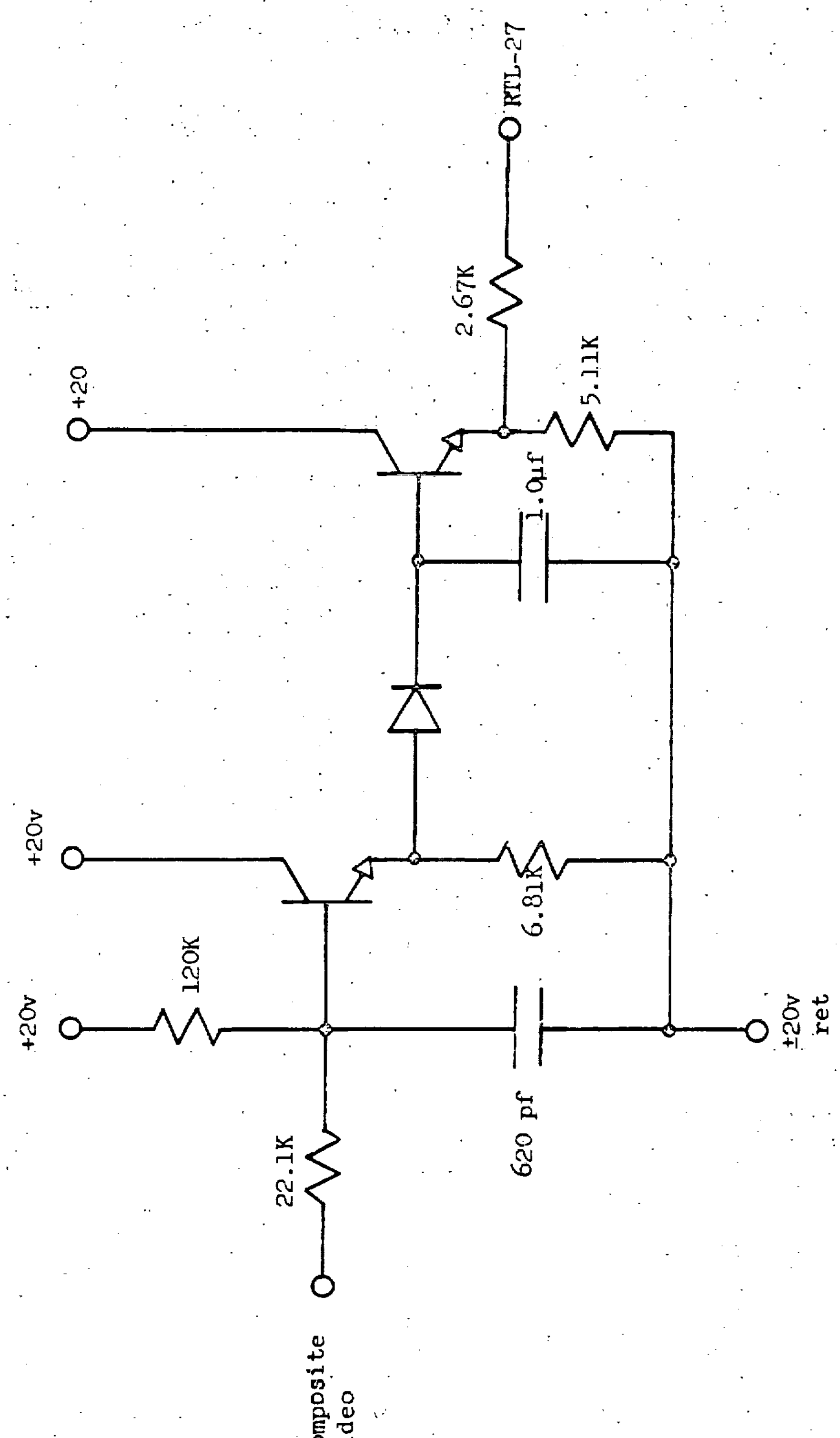



Figure 5-5. Typical Circuit 8




9.

Figure 5-6. Typical Circuit 9

10.

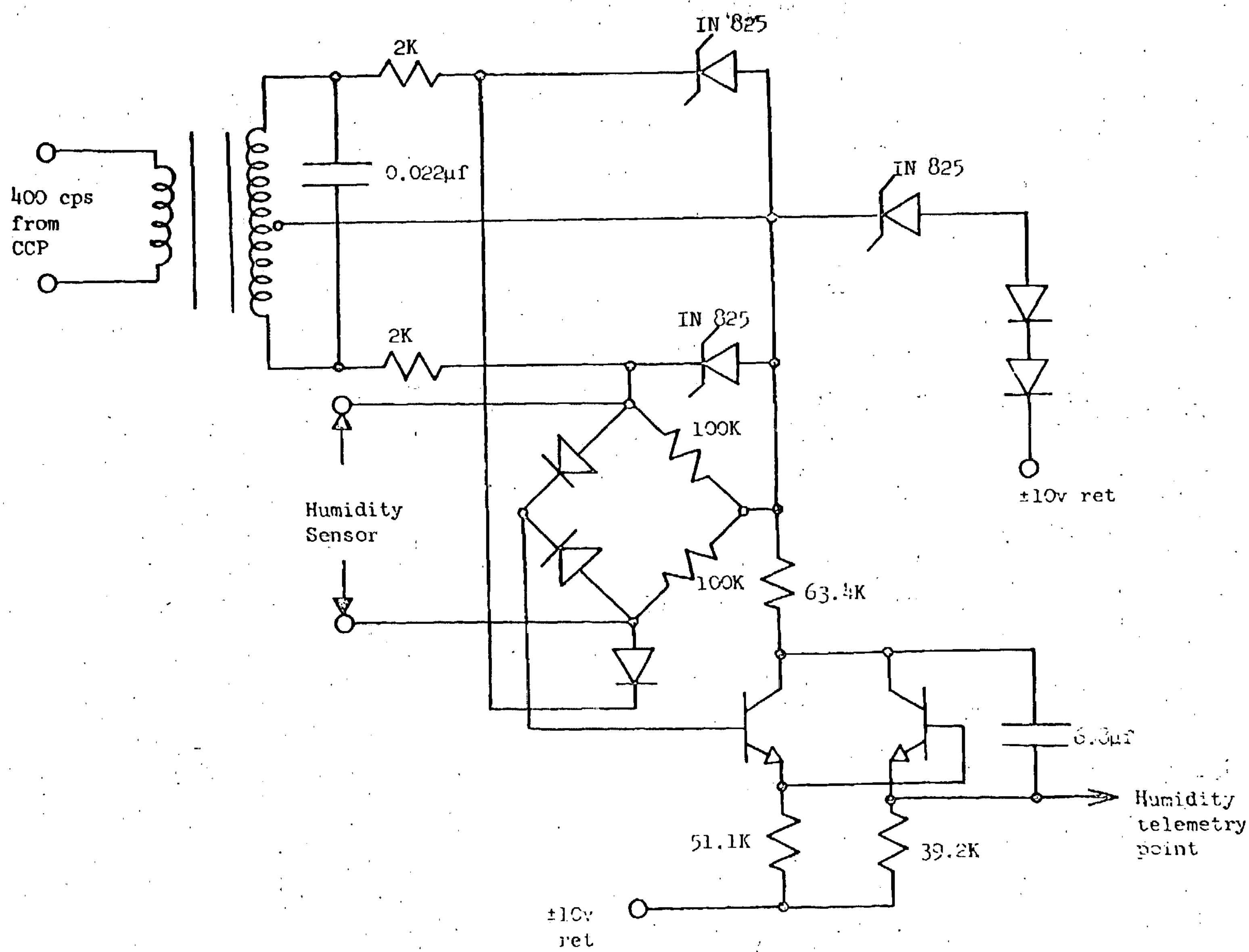



Figure 5-7. Typical Circuit 10

11.

12.

13.

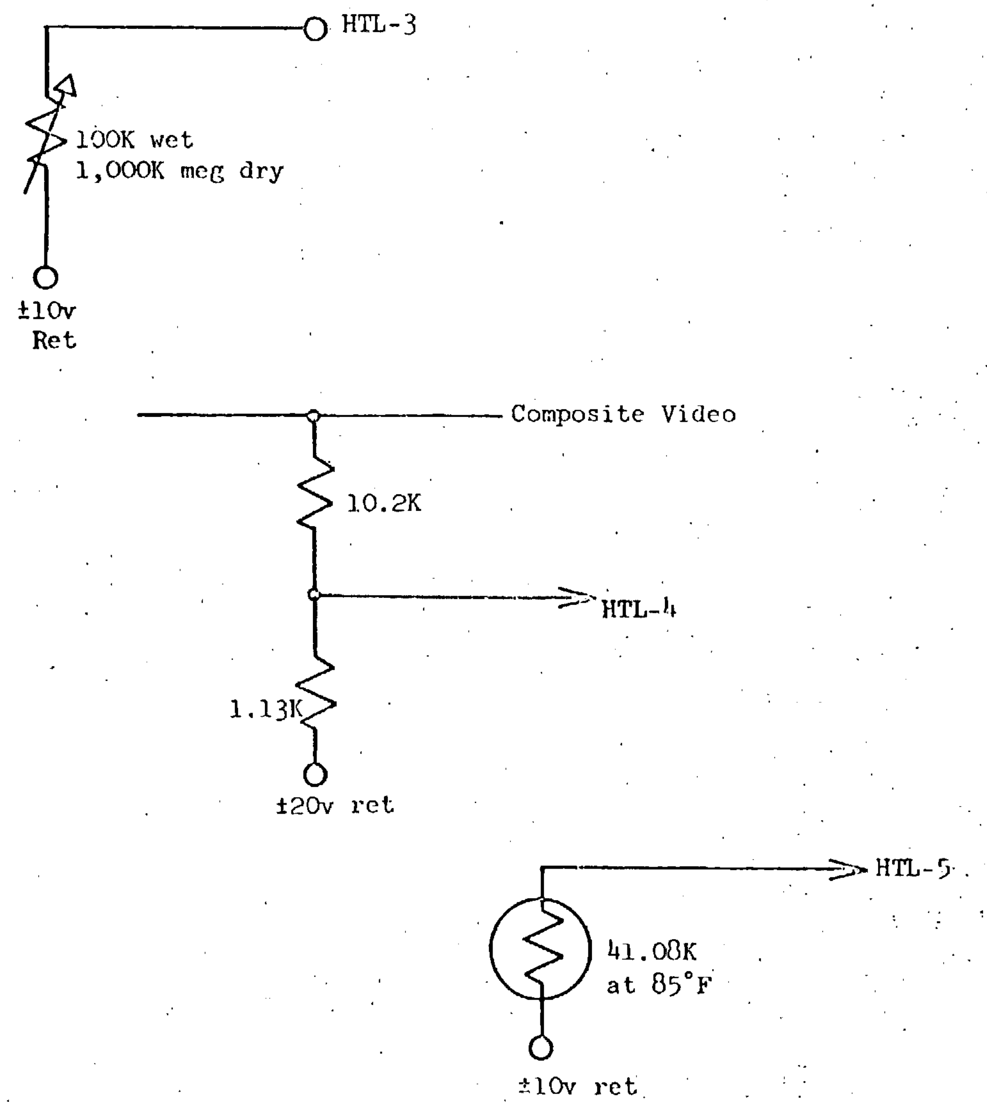



Figure 5-8. Typical Circuits, 11, 12, and 13

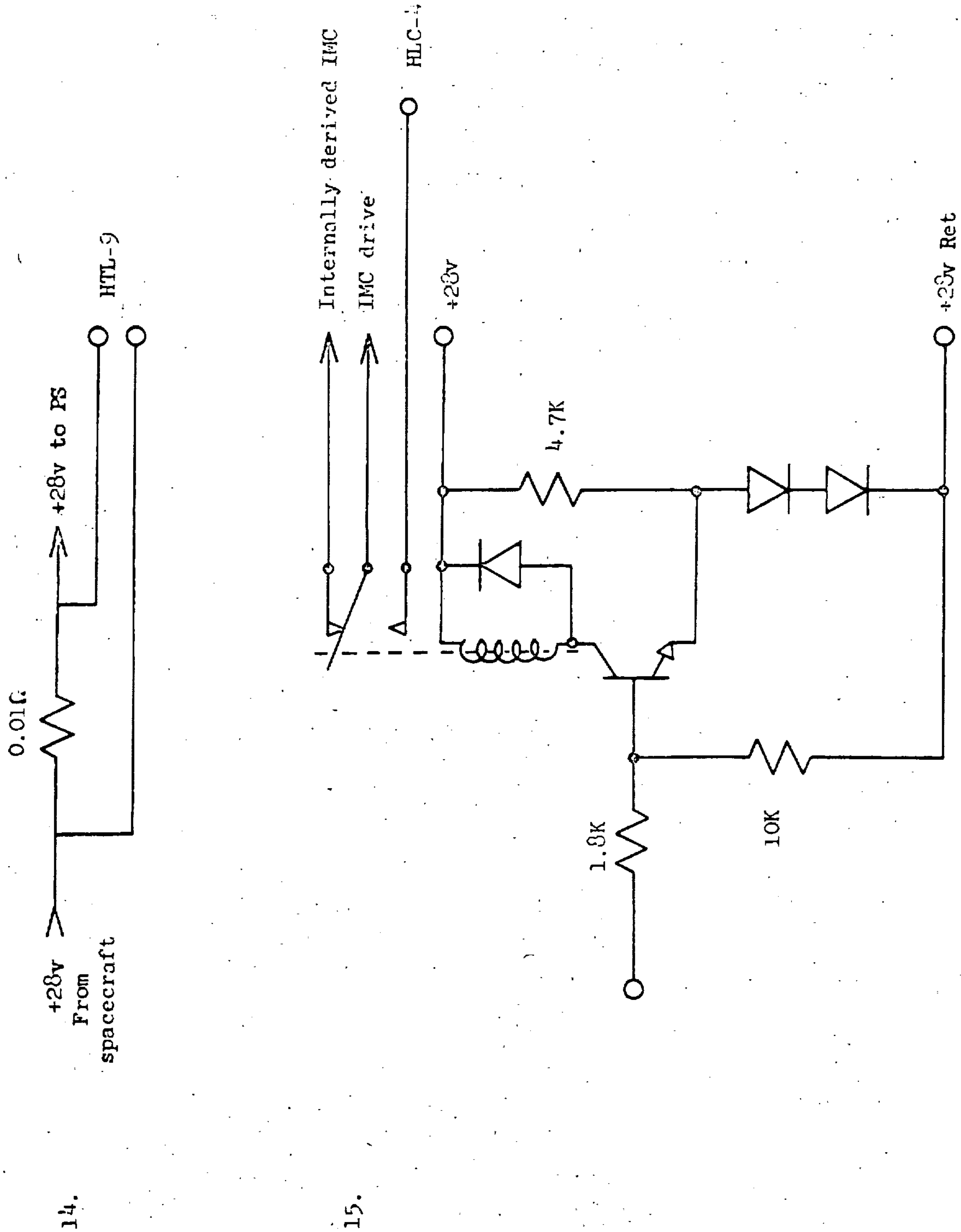
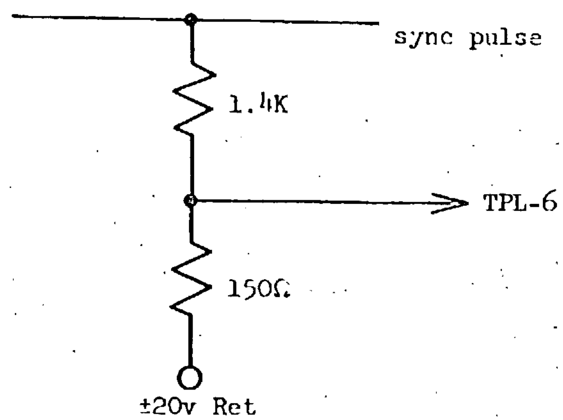



Figure 5-9. Typical Circuits, 14 and 15

16.




17.

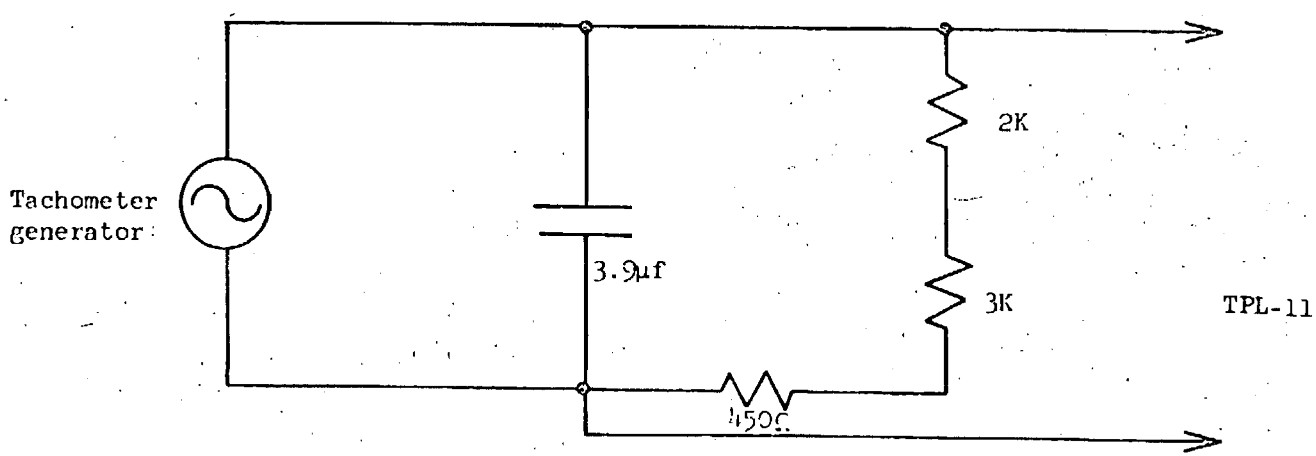



Figure 5-10. Typical Circuits, 16 and 17

# SECTION 6
# SYSTEM OPTICAL PERFORMANCE

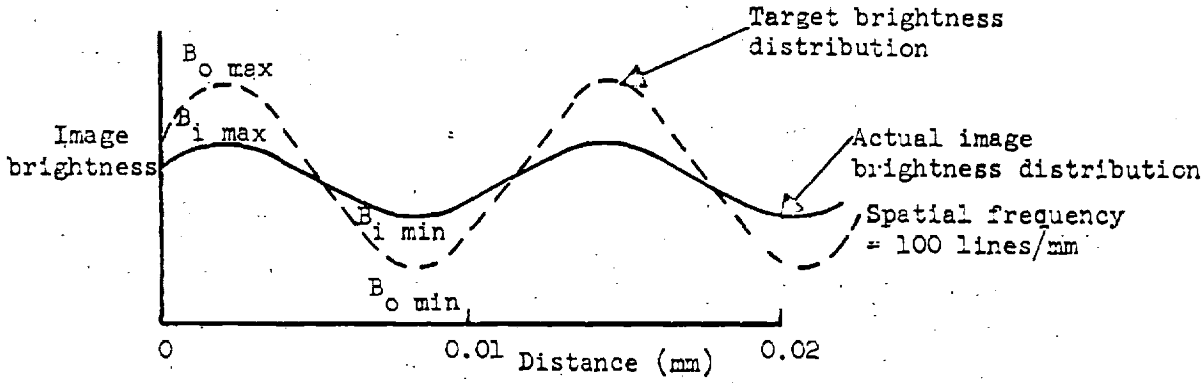
## 6.1 RESOLUTION

Resolution is a measure of the ability of an optical system to distinguish between closely spaced objects under specific viewing conditions. For example, a photograph is said to have 2-meter ground resolution at a specific contrast when light stripes 1-meter wide, 1-meter apart, and 5-meters long, with a contrasting dark background, are distinguishable.

Resolving power depends on a number of variables, such as: lens quality, image smear, contrast, and film quality. These variables can be analyzed by making use of transfer functions in a method frequently called sine-wave response. This method is analogous to the determination of the transfer function of electronic circuitry where each element in the optical system can be regarded as a low-pass filter. The sine-wave response method gives the bandpass characteristics of each photographic element as a function of spatial frequency. The system can be divided into elements where the output of each element is treated as an input to the next element, and so on (for example, the quality of the image formed by the lens at the film plane is independent of the smear caused by IMC errors). The sine-wave response function of each of the elements can be multiplied to obtain the combined effect of all of the elements in the system, yielding the system sine-wave response function. This function is used to predict image quality as presented to the film; knowledge of the film response characteristics make it possible to predict the performance of the system. Each of the variables affecting system resolution is discussed in the following paragraphs.

6.1.1 Lens Modulation Transfer Function (MTF)

6.1.1.1 Definitions. The MTF of a lens is a function which relates image modulation to target modulation as a function of spatial frequency. As shown in the following sketch, the lens reduces the amount of contrast (or signal) in the image:



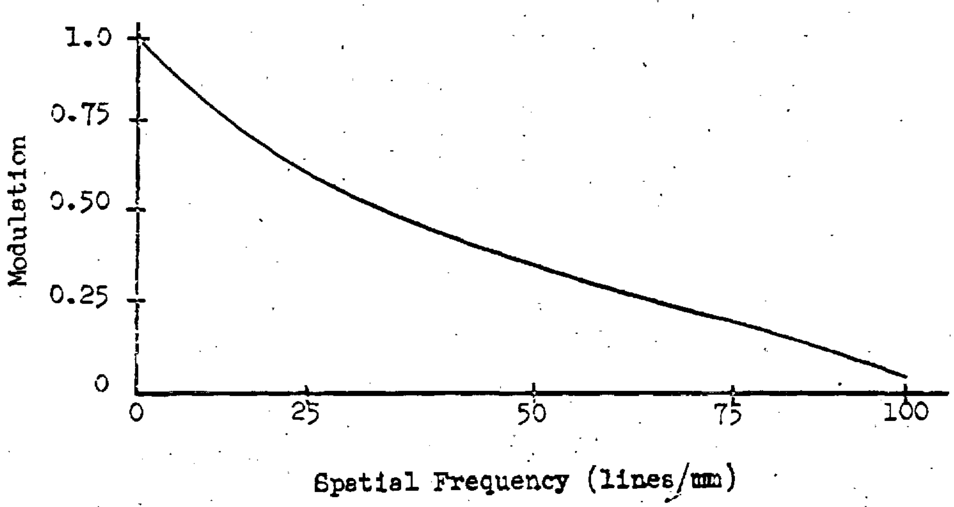

In this sketch, contrast is defined as

$$C = \frac{B\ max}{B\ min}$$

and modulation by

$$M = \frac{B\ max - B\ min}{B\ max + B\ min} = \frac{C - 1}{C + 1}$$

As shown in the sketch, passage of the input sine-wave of contrast $C_o = \frac{B_{o\ max}}{B_{o\ min}}$ through the lens results in an output sine-wave of $C_i = \frac{B_{i\ max}}{B_{i\ min}}$ where $C_i < C_o$, and of course, $M_i < M_o$. The MTF of the lens specifies the amount of modulation which will be present in the image for a specific object modulation and at a specific spatial frequency. A typical MTF curve is sketched below:



6.1.1.2 Lens MTF. The MTF of a lens for which the lens formula is known can be determined analytically in several ways; one of the most common and useful is through ray-tracing techniques. Ray-tracing is described in detail in standard texts and articles; therefore, it will not be described here.

2.1.1.2.1 24-Inch Lens. Through the use of an EKC computer program, the 24-inch lens was ray-traced and the MTF determined for 7 wavelengths, at 11 field positions. The parameters are listed below:

| Wavelength (mμ) | Field Positions (degrees) | |
|---|---|---|
| 404.7 | 0.0 | 7.0 |
| 435.9 | 1.0 | 8.0 |
| 486.1 | 2.0 | 9.0 |
| 546.1 | 3.0 | 10.4 |
| 589.3 | 4.0 | |
| 656.1 | 5.0 | |
| 700.0* | 6.0 | |

Approximately 3,050 rays were used in making each analysis. The lens formula input to the program included the effect of the aspherized front surface of the first element, the central obstruction of the lens, and the correct glass-nitrogen refractive indices(for nitrogen at 1.5 psia). The MTF's from the 7 wavelengths were then weighted according to the spectral response of the lens-film system to provide an estimate of the heterochromatic lens MTF. These MTF's are plotted in Figures 6-1, 6-2, and 6-3. Note: These MTF curves apply to a lens built exactly to the formula. Manufactured lenses can approach this performance as a limit. To calculate the performance of a typical manufactured lens, the MTF must be degraded slightly.

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* Glass indices calculated at this point using Hertzberger's formula.

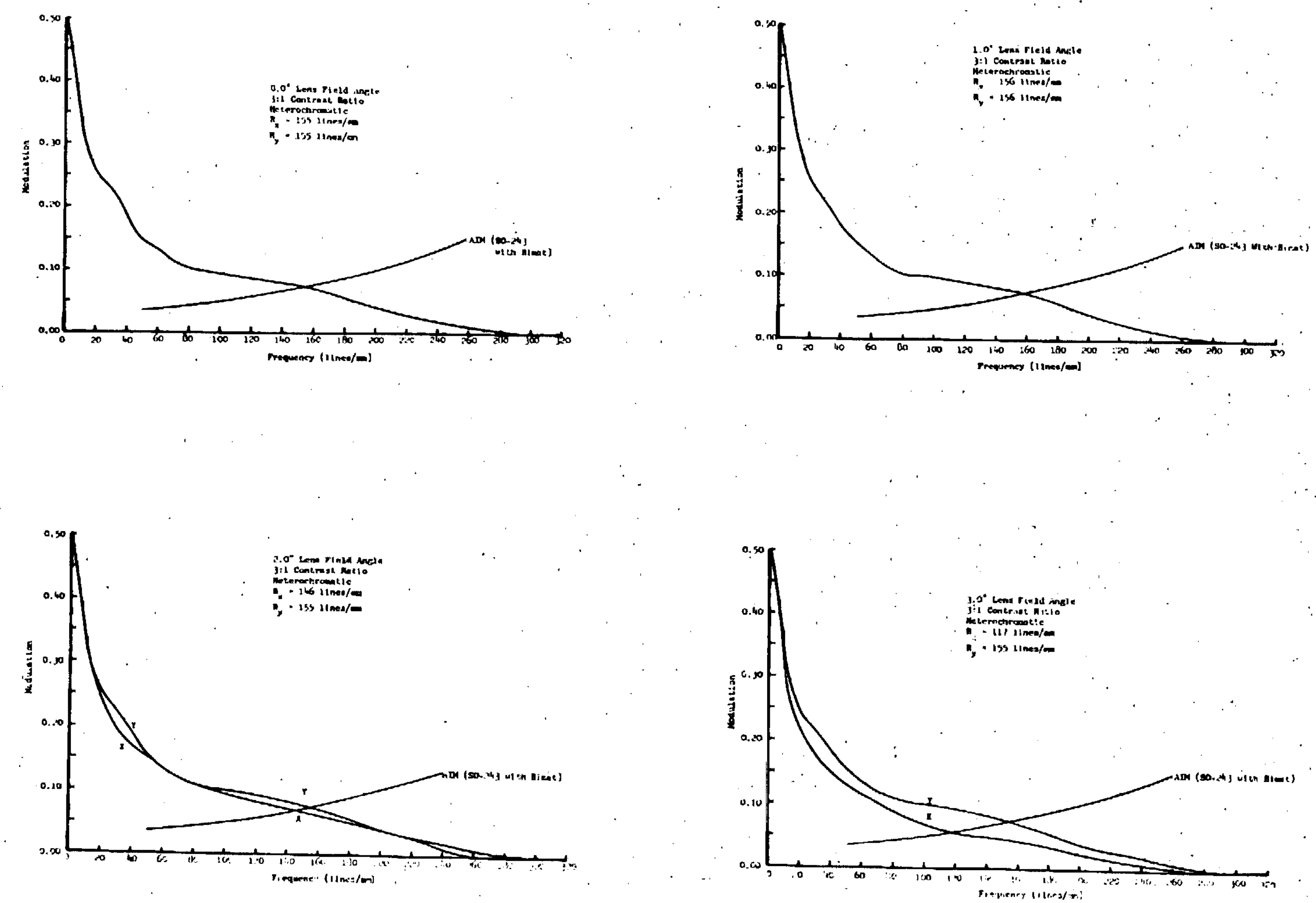


Figure 6-1. Heterochromatic MTF of 24-Inch Lens Built Exactly to the Formula

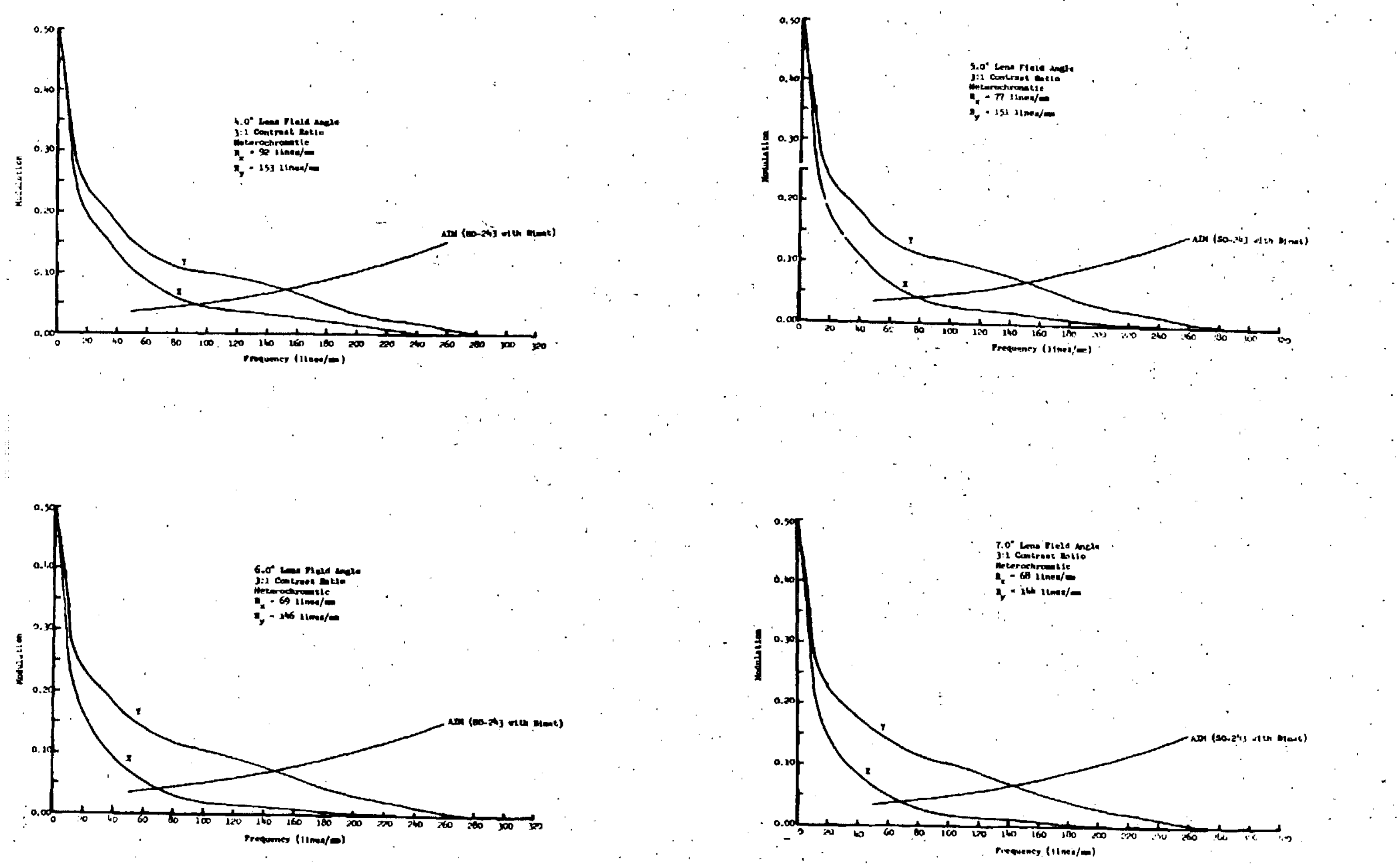


Figure 6-2. Heterochromatic MTF of 24-Inch Lens Built Exactly to the Formula

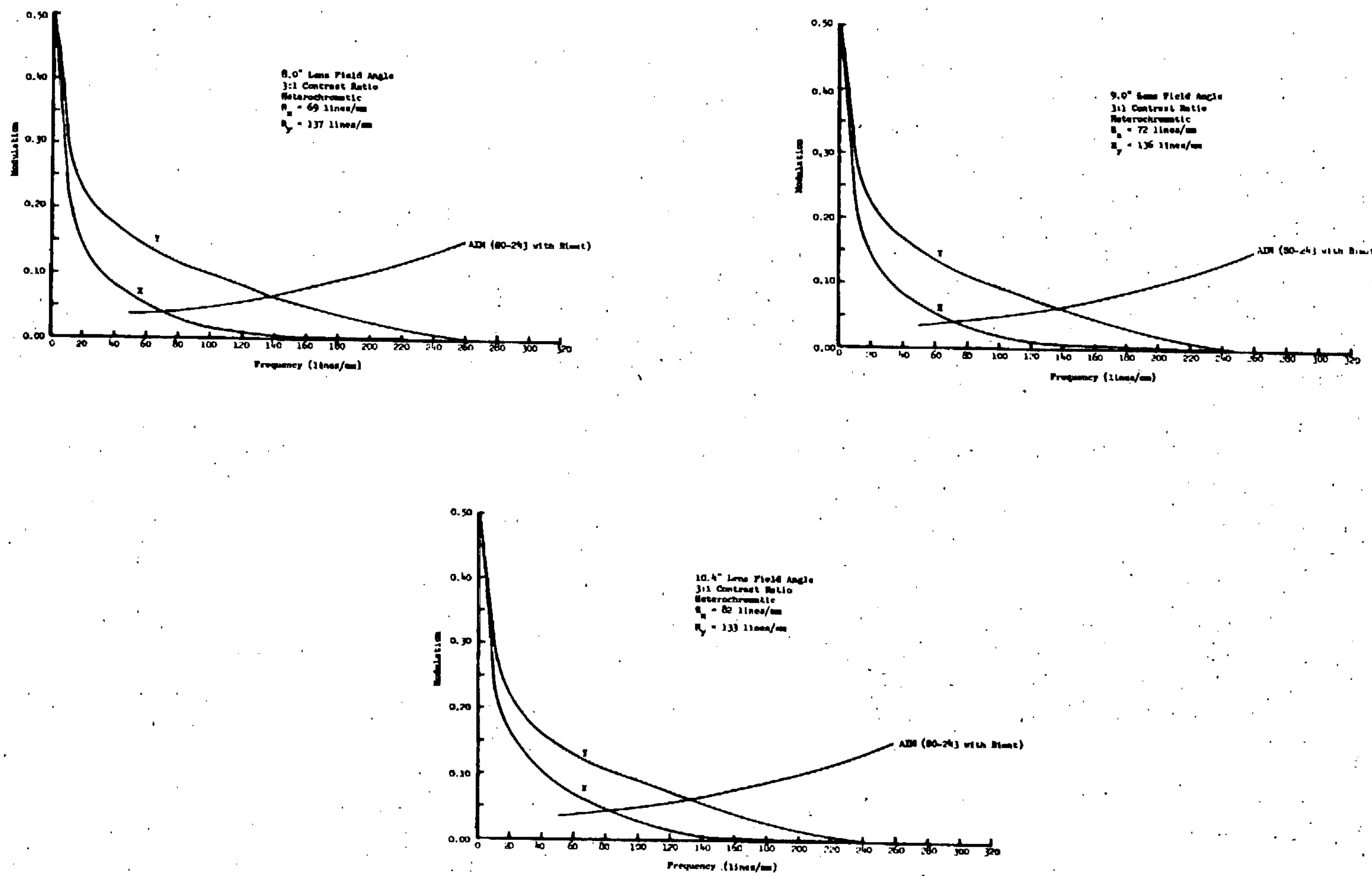


Figure 6-3. Heterochromatic MTF of 24-Inch Lens Built Exactly to the Formula

The MTF can be degraded by assuming that the lens manufacturing tolerances follow a gaussian probability distribution. The lens response can then be specified by multiplying the perfect lens MTF by the MTF of a gaussian spot whose size is proportional to the size of the manufacturing tolerances encountered. The MTF of a gaussian spot is shown in Figure 6-4. The on-axis, heterochromatic lens response, both before and after a typical gaussian degradation, is shown in Figure 6-5.

In addition, the resolution of a perfect 24-inch lens was calculated over a focus error range of ±0.0015 inches, on-axis. The curve is plotted in Figure 6-6. The assumed focal plane tolerance of ±0.001 inches thus results in a loss of about 9 lines/mm.

6.1.1.2.2 80-mm Lens. The MTF of the 80-mm lens was determined by ray tracing as described above. For this lens, whose purpose is to provide moderate resolution photographs, the analysis was restricted to the following ranges:

| Wavelength (mμ) | Field Positions (degrees) |
|---|---|
| 486.1 | 0.0 |
| 546.1 | 7.0 |
| 589.3 | 14.0 |
| 656.1 | 21.0 |
| | 28.0 |

The MTF's were then weighted to provide an estimate of the heterochromatic lens response as described above. The heterochromatic MTF's are plotted in Figures 6-7 and 6-8. Resolution vs focus error is plotted in Figure 6-9.



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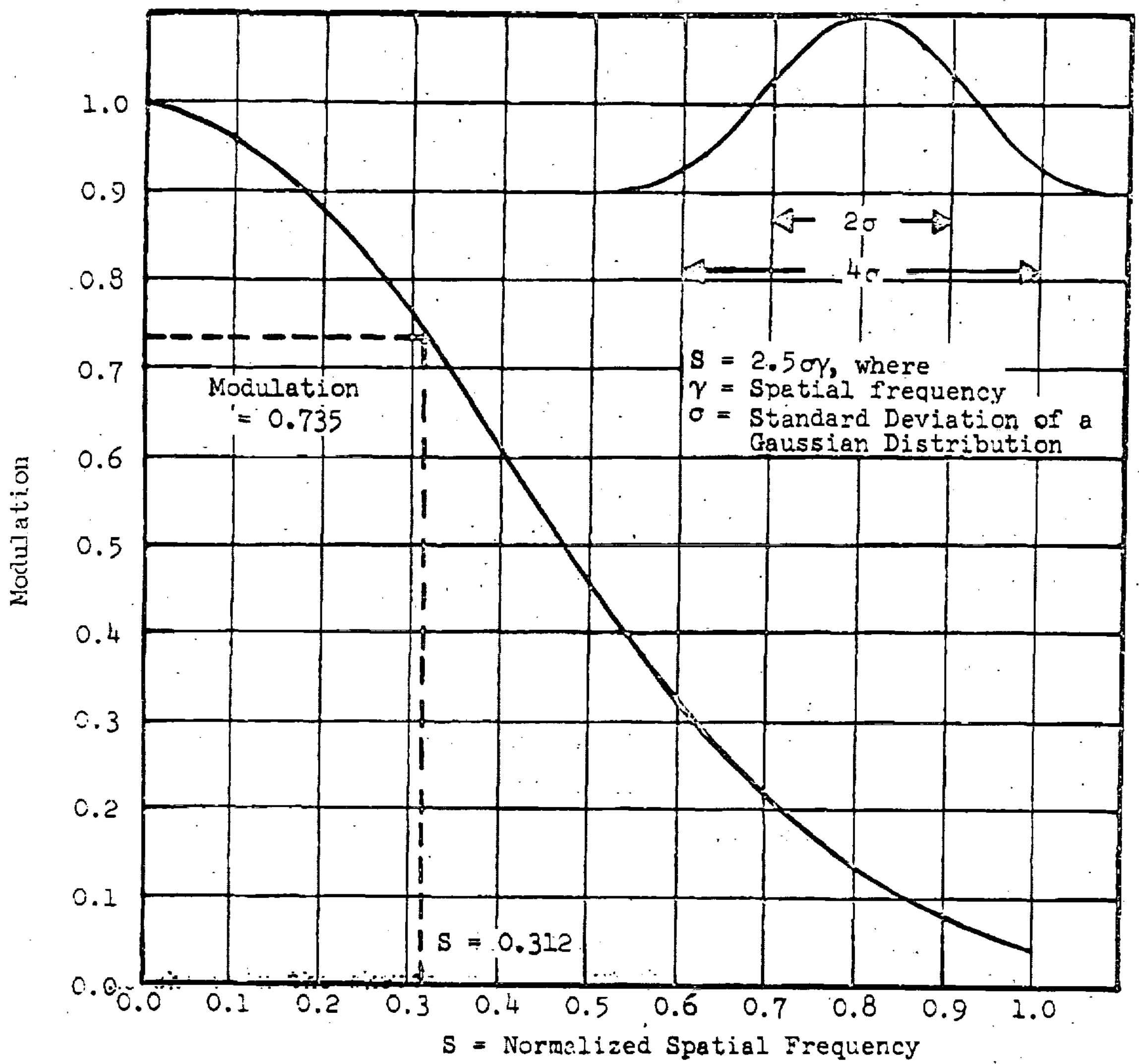


Example: Determine the Modulation of a 5 micron diameter (4σ) Gaussian spot at 100 lines/millimeter

Procedure:

1. Solve for $\sigma$: $\sigma = 4$

   $4\sigma = 0.005$mm, therefore $\sigma = 0.00125$ mm $\gamma = 100$ lines/millimeter

2. Solve for S

   $$S = 2.5\sigma\gamma = (2.5)(0.00125\text{mm})(100\ \frac{\text{lines}}{\text{mm}}) = 0.312$$

3. Read Modulation for S = 0.312 from Figure 6-4

4. Response for this Gaussian spot is 0.735 at 100 lines/millimeter

Figure 6-4. Modulation Transfer Function of a Gaussian Spot

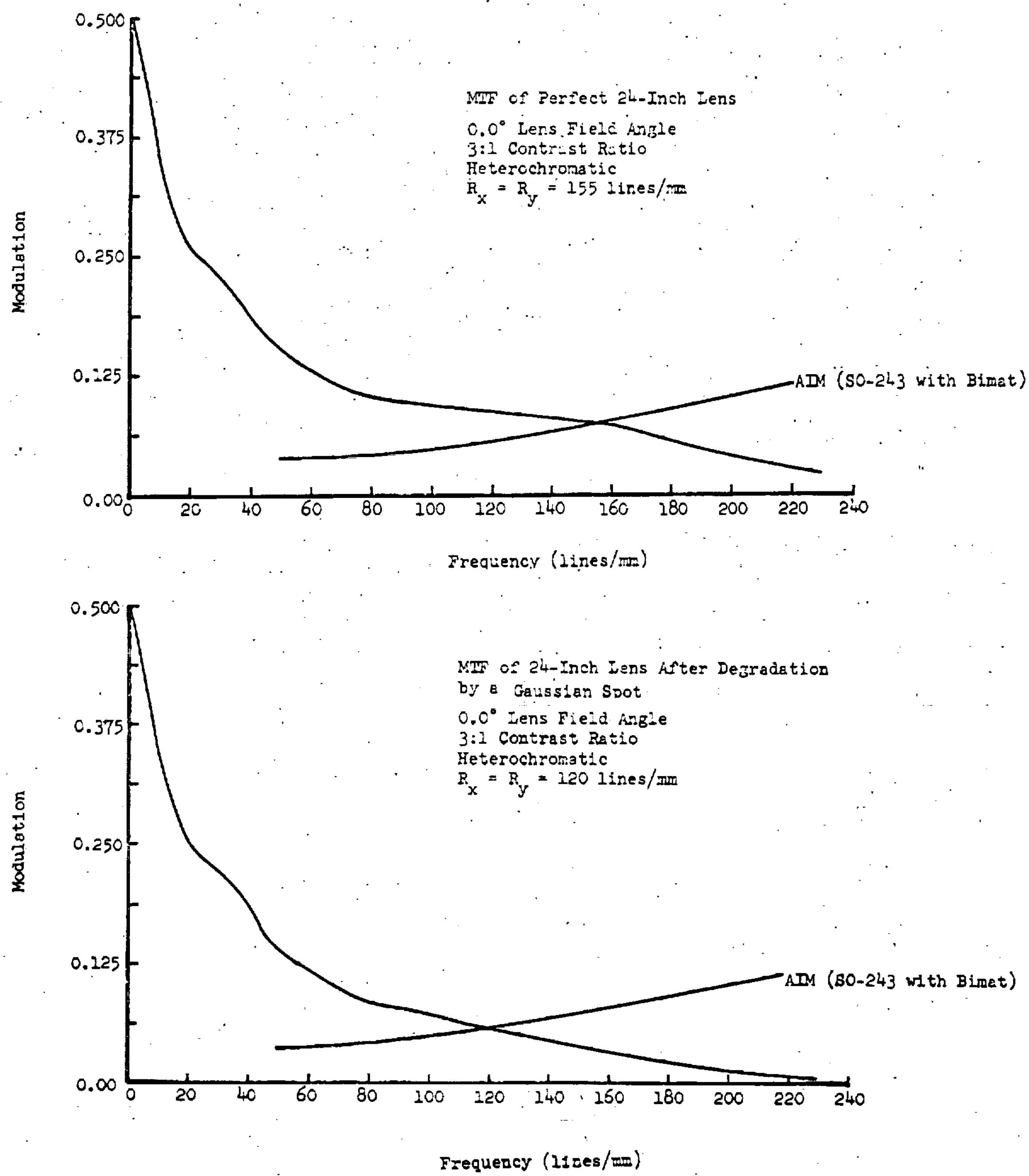


Figure 6-5. Degradation of Lens MTF by a Gaussian Spot

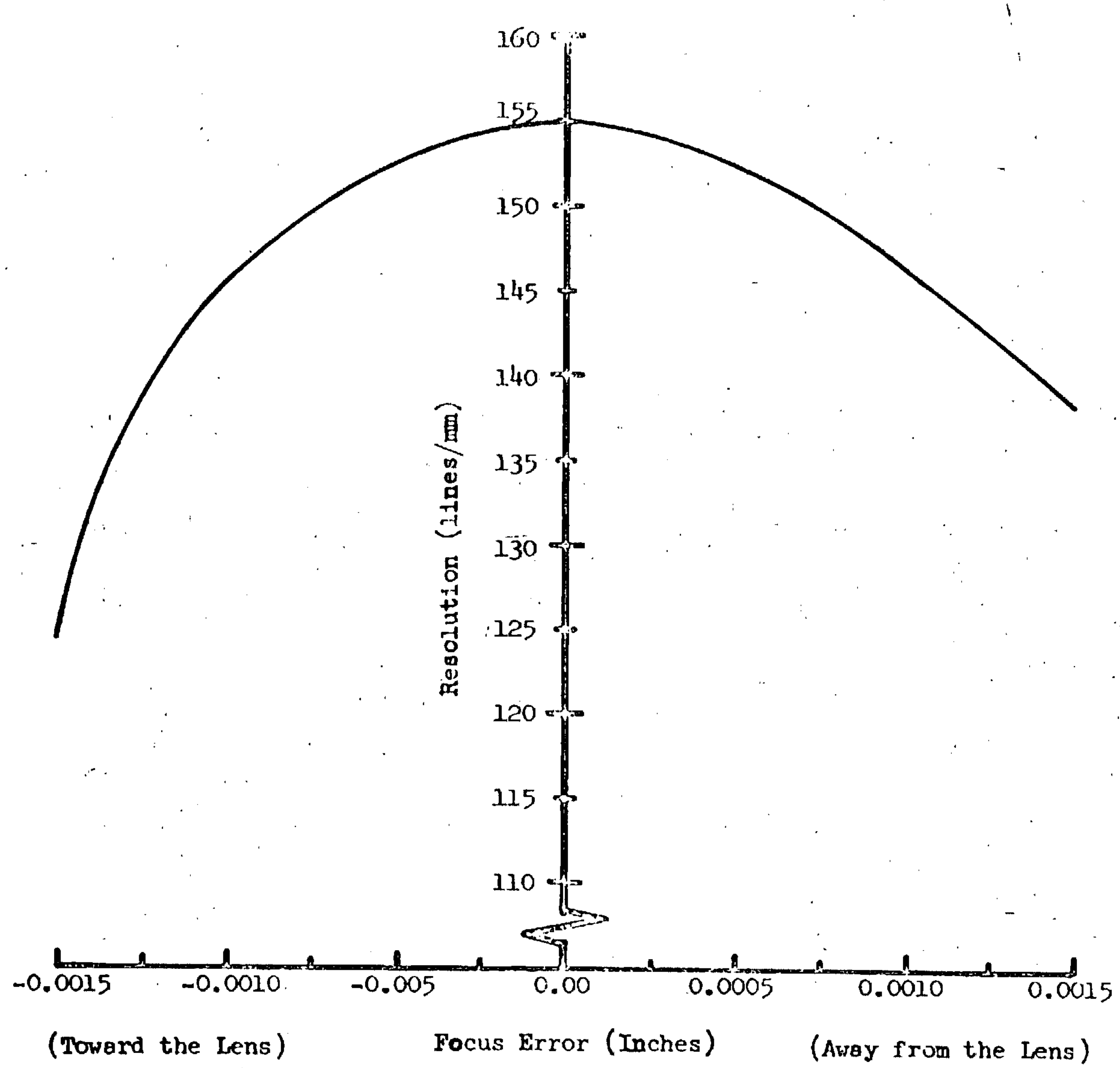


Figure 6-6. Resolution vs Focus Error for the 24-Inch Lens, On-Axis, Heterochromatic, 3:1 Contrast, for a Lens Built Exactly to the Formula

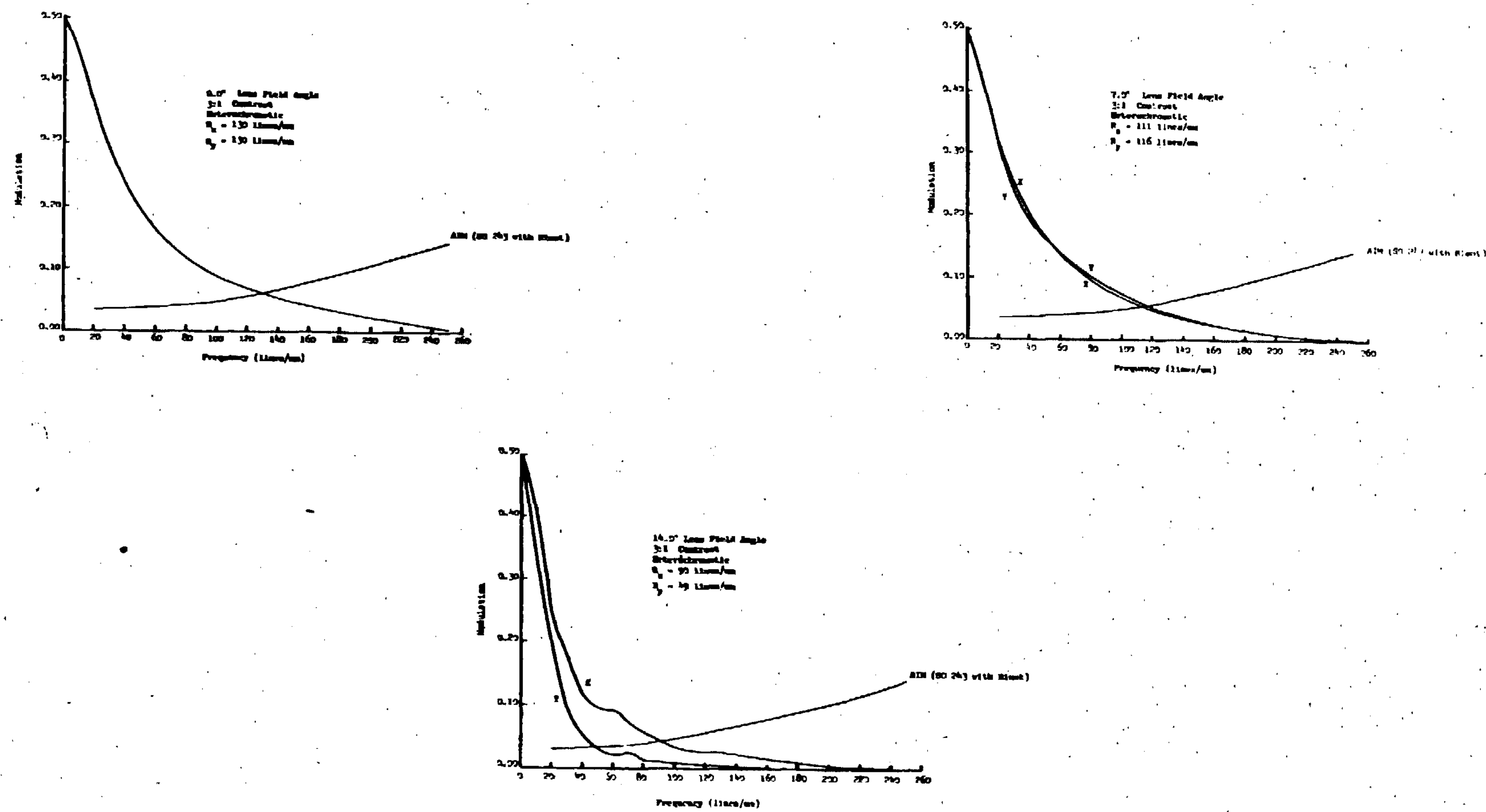


Figure 6-7. Heterochromatic MTF of 80-mm Lens Built Exactly to the Formula

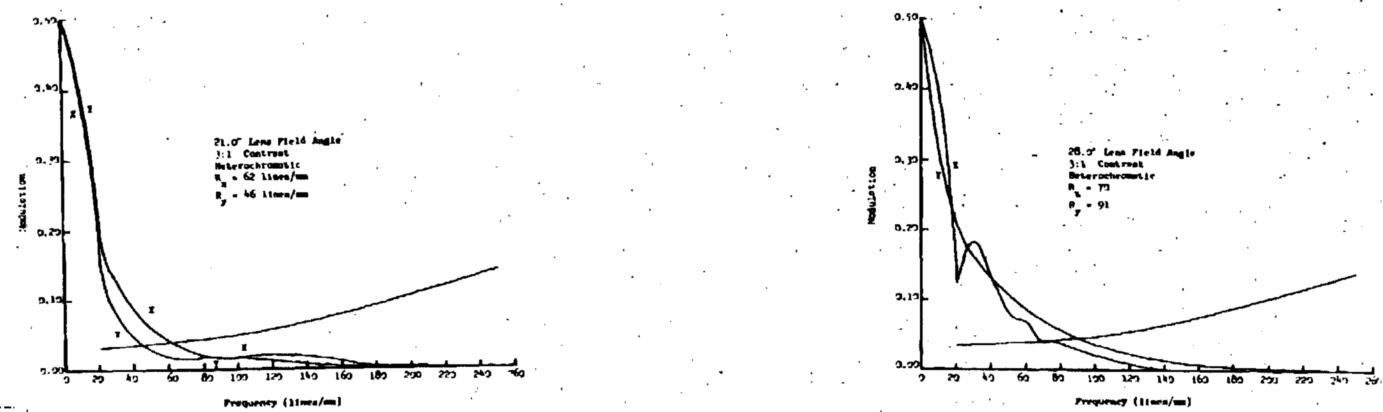




Figure 6-8. Heterochromatic MTF of 80-mm Lens Built Exactly to the Formula

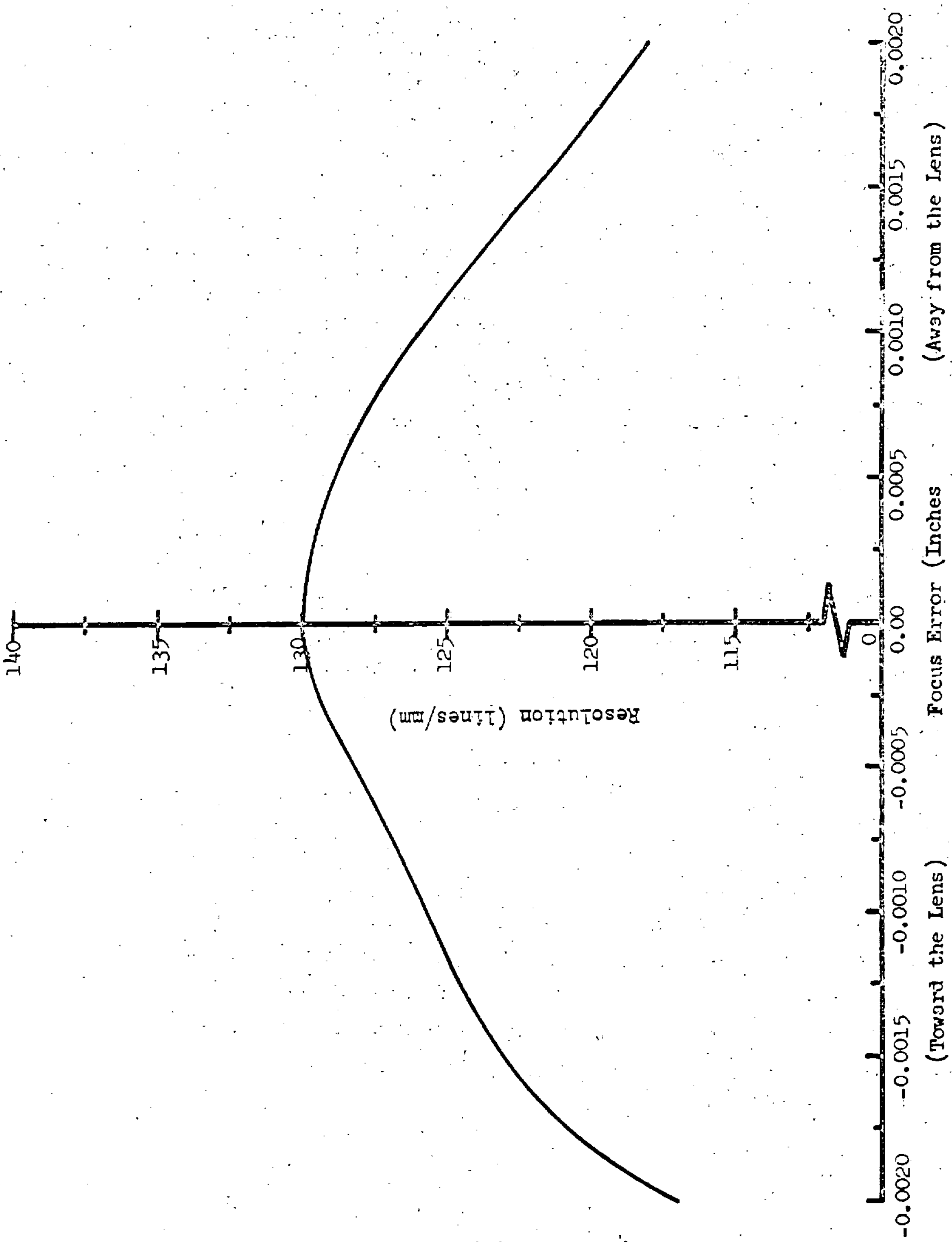


Figure 6-9. Resolution vs Focus Error for the 80-mm Lens, On-Axis, Heterochromatic, 3:1 Contrast, for a Lens Built Exactly to the Formula

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### 6.1.2 Aerial Image Modulation

The resolution of the lens-film combination can be predicted by determining the minimum modulation which will produce a detectable image on the film (as a function of spatial frequency).

The threshold modulation level to which the film will respond and produce a distinguishable density difference is an inherent property of the film and is related to the MTF of the film. The modulation required for detectability can be measured, and after dividing out the MTF of the test lens, the minimum modulation curve for the film can be determined. This curve is called the Aerial Image Modulation Curve, or AIM curve for the film.

The AIM curve for Type SO-243 Film with Bimat processing is included with the lens MTF curves in the preceding figures. The point of intersection of the two is the limiting resolution of the lens-film system.

### 6.1.3 Contrast

As given in paragraph 6.1.1, contrast is defined by $C = \frac{B\ max}{B\ min}$ and modulation is $M = \frac{B\ max - B\ min}{B\ max + B\ min} = \frac{C - 1}{C + 1}$.

The limiting modulation presented by a lens to the film cannot be greater than the inherent modulation of the target itself. Both optical theory and photographic tests have shown that this limiting modulation is transferred with no degradation through the lens at frequencies near zero. Hence, for a target contrast of 2:1, the maximum image modulation is 0.333; for 5:1, the maximum modulation is 0.667.

The effects of contrast changes on the 24-inch lens MTF is shown in Figure 6-10. Note that the lens-film resolution varies substantially over the illustrated contrast range. Based on this data, it is possible to plot resolution vs object contrast. For the 24-inch lens, this relation is plotted in Figure 6-11, for lenses of several peak resolutions.

6.1.3.1 Lunar Surface Contrast. This topic is discussed in detail in paragraph 6.3.5. In Section 7, several photographs simulating the lunar surface are included to illustrate the effect of solar altitude on lunar surface contrast.

## 6.2 IMAGE SMEAR

This section describes the method used to calculate Photo-Subsystem image smear. Smear contributors are separated into mission-variable, mission-constant, and zero-error classifications. Each contributor is assigned an error distribution and a 3-sigma error limit. Smears from each contributor are then calculated for several points in the image plane. The calculated smears are averaged at each point and over the entire frame.

The vehicle is assumed to be correctly aligned for photography at perilune, except for attitude errors. Smears are calculated at five points along the orbit: $\theta = \pm 3.5$ degrees, $\pm 0.88$ degrees, and 0.0 degrees, where $\theta$ is the angular advance from perilune. These angular advances are those which would occur for 16-frame slow- and fast-camera framing rates respectively.

### 6.2.1 Definitions

Image smear. In aerial or satellite photography, the image in the focal plane moves at a rate proportional to the focal length of the lens and the altitude and velocity of the satellite. As a result of this motion the image can move during the exposure, the movement is called image smear.

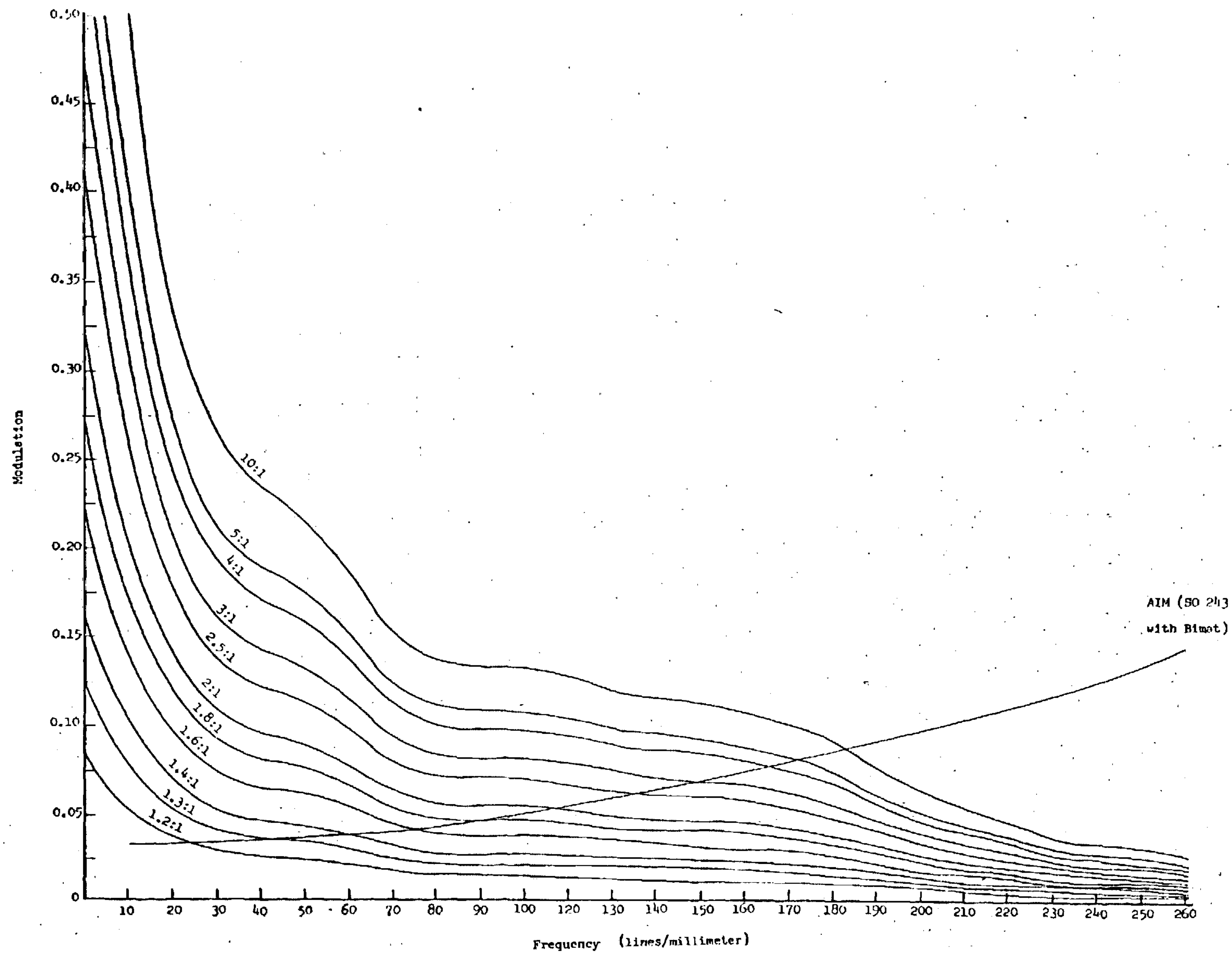



Figure 6-10. MTF of 24-Inch Lens for Several Contrast Ratios. (Perfect Lens MTF's degraded with a Gaussian spot to produce a resolution of 141 lines/mm at 3:1 Contrast)

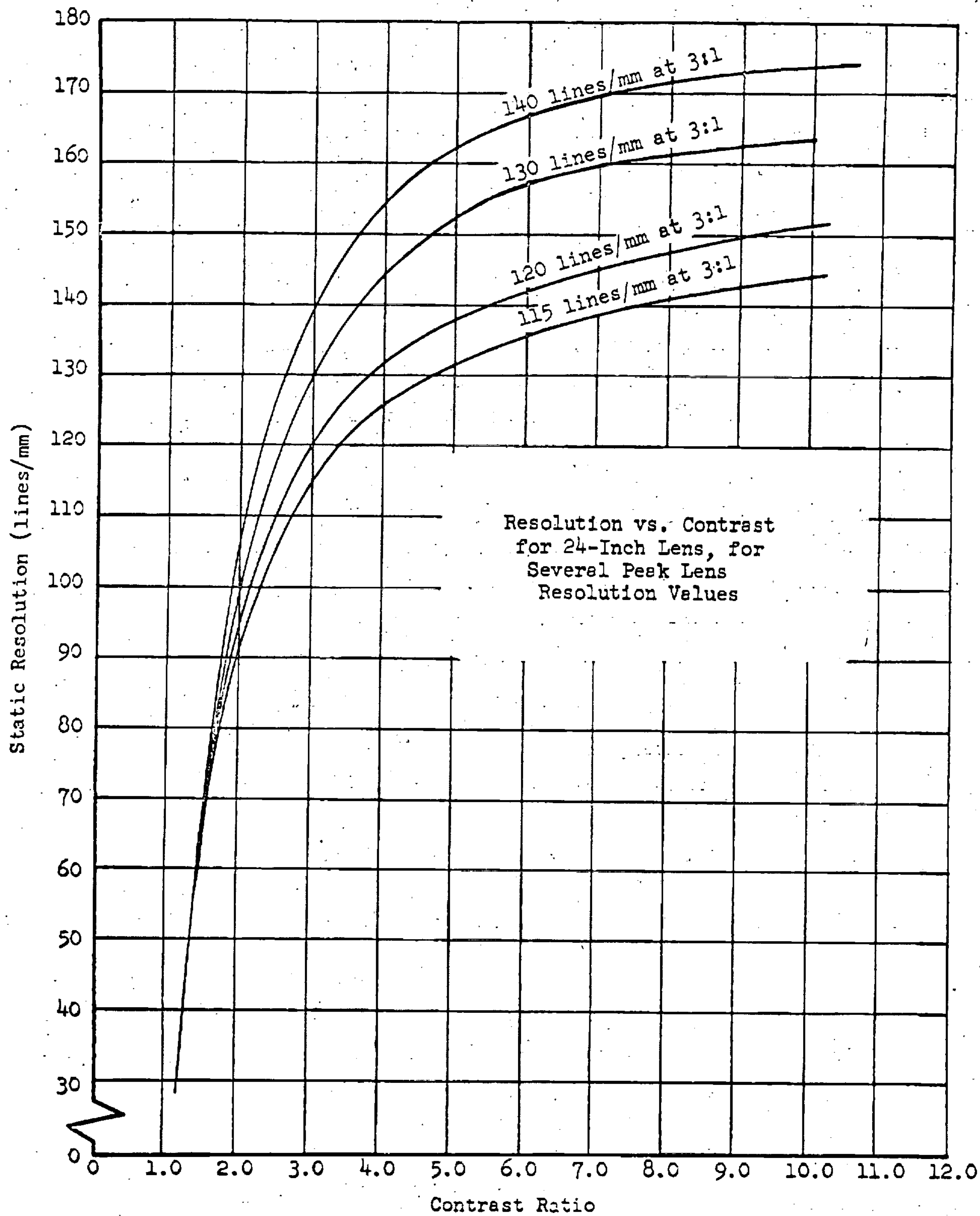



Figure 6-11. Resolution vs Contrast for 24-Inch Lens, For Several Peak Lens Resolution Values.

<u>Image motion compensation (IMC).</u> To produce high quality photography, the film is moved in near synchronism with the image during exposure; this film movement is called Image Motion Compensation (IMC). Because it is not possible to move the film in perfect synchronism, image motion is not completely compensated; the residual motion is known as smear.

A constant smear rate throughout the exposure is known as linear smear.

### 6.2.2 Image Smear and Resolution

Image smear and resolution are related; the greater the smear magnitude, the less resolution is obtainable from a given system. The interrelationship of resolution and image smear is normally determined using modulation transfer functions.

6.2.2.1 <u>Smear Modulation Transfer Function.</u> Most smear contributors introduce a constant smear rate during exposure, resulting in linear smear. In Figure 6-12, the effect of smearing test targets by an amount (a) is shown. It can be seen that two effects occur:

| Tri-Bar Targets | Sinusoidal Targets |
|---|---|
| a. The brightness profile of the tri-bars is no longer rectangular, | a. A phase shift occurs, |
| b. The contrast is reduced. | b. The contrast is reduced. |

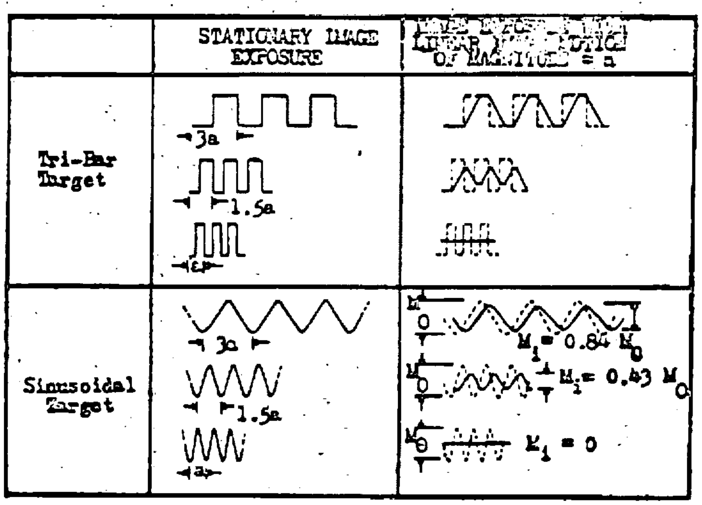



Figure 6-12. Test Target Smear Effect

For the purposes of analysis, only the sinusoidal targets will be treated in this section.

A number of authors have shown that the MTF of linear smear for sinusoidal targets can be defined by the function: $M(k) = \frac{\sin \pi ak}{\pi ak}$

where $a$ = magnitude of image motion (microns)

$k$ = spatial frequency (lines/mm)

$M(k)$ = modulation at frequency $k$

This relation is plotted in Figures 6-13 and 6-14 both normalized and for a range of image smears. Because the phase shift which occurs during smear does not affect the information content of the photograph, its effect will be ignored.

6.2.2.2 Image Smear as a Vector. Image smear has both magnitude and direction. Therefore, it is a vector quantity and can be resolved into components parallel and perpendicular to the direction of film, or platen, motion. In this section,

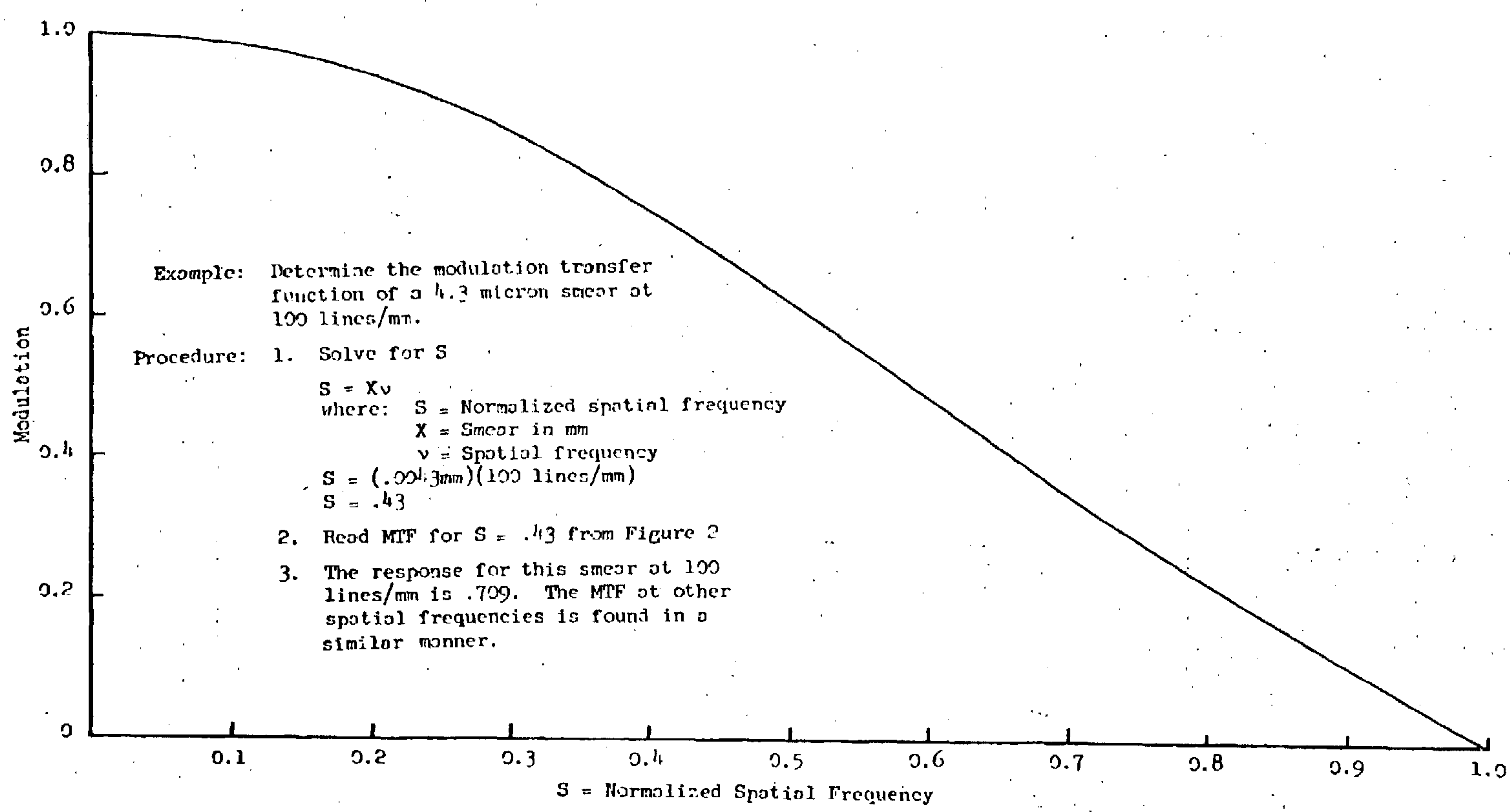



Figure 6-13. Modulation Transfer Function of Linear Smear

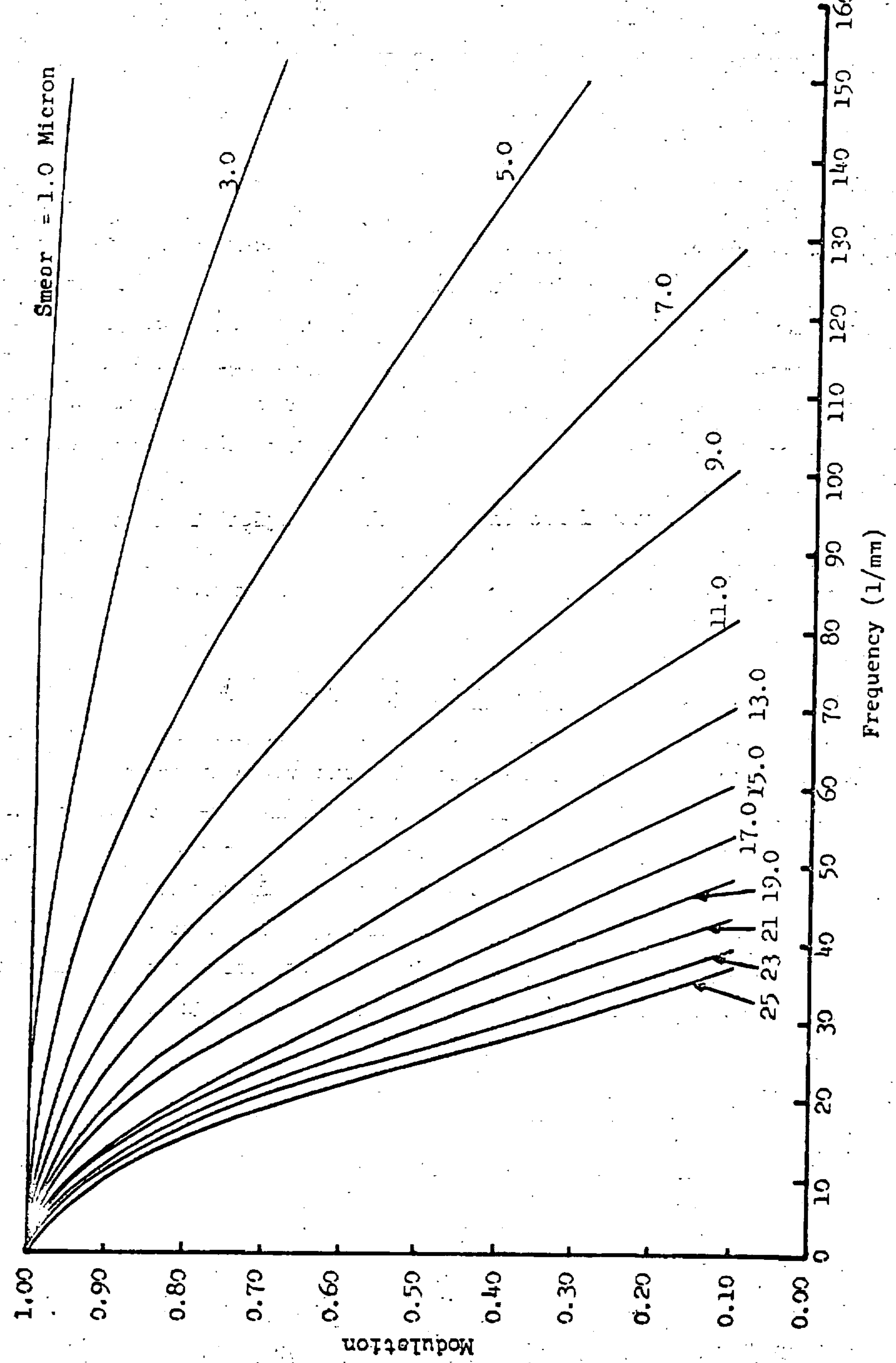



Figure 6-14. MTF of Linear Image Smear

image smear parallel to the direction of platen motion is called X-smear; image smear perpendicular to the direction of platen motion is called Y-smear.

### 6.2.3 Calculation of Image Smear

The magnitude and the direction of image smear are determined separately for each smear contributor. Tolerances at the 3-sigma confidence level are used to describe smear contributors, and consequently smear magnitude is calculated at the 3-sigma level. Each smear vector is resolved into X and Y components. Total 3-sigma X and Y smears are calculated separately as the root-sum-squares of the individual smears. This general method of combining smears is discussed in paragraphs 6.1.3.1 and 6.1.3.4.

6.2.3.1 Smear Contributors. The smear contributors for the LOP system, the assumed error distribution, tolerance limits, and 3-sigma error limits are listed in Table 6-1.

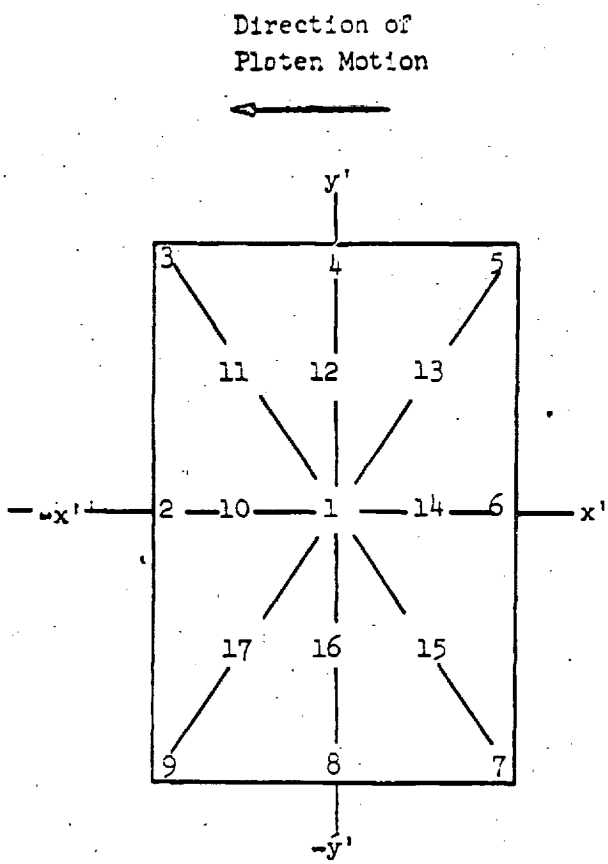
6.2.3.2 Image Smear Across the Frame. Image smear from a given contributor can vary in both magnitude and direction across the frame. In some cases, a smear contributor does not produce a significant smear at or near the center of the frame; however, it will cause significant smears near the edge of the frame. Smear tolerances must take such variations into account. Image smear was computed at 17 different frame positions. These positions are numbered and are shown in Figure 6-15. The field angles corresponding to each numbered position are also shown in Figure 6-15, for the 55 by 219-mm high-resolution frame and for the 55 by 65-mm low-resolution frame.

TABLE 6-1

TOLERANCES AND 3-SIGMA ERRORS OF SMEAR CONTRIBUTORS

| Mission-Variable Errors | Assumed Error Distribution | Tolerance Limits | 3-Sigma Error |
|---|---|---|---|
| Roll, pitch, and yaw position | Uniform* | ±0.2 degrees | ±0.346 degrees |
| Roll, pitch and yaw rates | Skewed Gaussian* | ±0.01 degrees/sec | ±0.01 degrees/sec |
| V/H sensor crab measurement error | Gaussian | ±0.33 degrees | ±0.33 degrees |
| V/H sensor measurement error | Gaussian | ±0.206 millirad/sec | ±0.206 millirad/sec |
| Terrain variability | Gaussian | ±0.5% of 46 km perilune altitude | ±0.5% of 46 km perilune altitude |
| Platen vibration | Gaussian | 7.5 microns X direction | 7.5 microns X direction |
| Mission-Constant Errors | | | |
| PS optical axis to S/C attitude control system alignment-roll, pitch and yaw position | Gaussian | ±0.5 degrees | ±0.5 degrees |
| V/H sensor to optical axis alignment error-roll, pitch and yaw position | Gaussian | ±0.1 degrees | ±0.1 degrees |

* Based upon verbal communication from Boeing personnel.




Field Angles for Numbered Frame Positions

| Frame Position Number | High-Resolution Frame (55 x 219mm) (Degrees) X | Y | Low-Resolution Frame (55 x 65mm) (Degrees) X | Y |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 2.58 | 0 | 18.97 |
| 3 | 10.18 | 2.58 | 22.11 | 18.97 |
| 4 | 10.18 | 0 | 22.11 | 0 |
| 5 | 10.18 | -2.58 | 22.11 | -18.97 |
| 6 | 0 | -2.58 | 0 | -18.97 |
| 7 | -10.18 | -2.58 | -22.11 | -18.97 |
| 8 | -10.18 | 0 | -22.11 | 0 |
| 9 | -10.18 | 2.58 | -22.11 | 18.97 |
| 10 | 0 | 1.29 | 0 | 9.75 |
| 11 | 5.13 | 1.29 | 11.48 | 9.75 |
| 12 | 5.13 | 0 | 11.48 | 0 |
| 13 | 5.13 | -1.29 | 11.48 | -9.75 |
| 14 | 0 | -1.29 | 0 | -9.75 |
| 15 | -5.13 | -1.29 | -11.48 | -9.75 |
| 16 | -5.13 | 0 | -11.48 | 0 |
| 17 | -5.13 | 1.29 | -11.48 | 9.75 |

Figure 6-15. Location of Numbered Frame Positions in External Platen Coordinate System.

### 6.2.4 Mathematical Methods

6.2.4.1 Basic Statistical Approach. Because there are many smear contributors whose magnitudes can vary randomly over a wide range, a statistical approach was developed by EKC to predict the smear magnitude for normal operating conditions.

Using this approach, smear contributors are separated into three groups. The first is zero-error smear, which is a function of the vehicle orbital position and velocity. The second consists of factors such as alignment errors, which remain constant during a given mission. The third consists of factors such as attitude rates, platen drive-velocity errors, etc., which vary from photograph to photograph during the mission. Therefore, each photograph has a zero-error smear, a constant smear, and a variable smear that fluctuates about the sum of the zero-error and mission constant smears. The three groups are further discussed below.

6.2.4.2 Zero-Error Smear. This category includes image smear that exists when all functions of the spacecraft perform at nominal, or zero-error, conditions. Sources of such image smear are moon-surface curvature, vertical component of vehicle velocity, and the forward look-angle of the V/H sensor and geometry. Zero-error smear varies with field angle. As defined zero-smear is independent of the mission-constant and mission-variable smears and therefore, not being random, its computed value is added directly to the root-sum-square smear of the other contributors.

6.2.4.3 Mission-Constant Smear Contributors. Mission-constant smear is caused by alignment errors; its magnitude is determined by design tolerances. Because alignment errors are random, mission-constant smear can vary from

one mission to the next, although it remains fixed for any one mission. The important alignment errors for the PS are the optical axis to S/C attitude-control-system alignment error and the V/H sensor to optical-axis alignment error. The PS optical axis to S/C attitude-control-system alignment error can be expressed as roll, pitch, and yaw about the optical coordinates. The V/H sensor to optical-axis alignment error can be expressed as a roll, pitch, and yaw about the spacecraft coordinates. Figure 6-16 is a sketch of the coordinate systems. All mission-constant alignment errors are assumed to have a Gaussian distribution. Mission-constant smears are calculated as the increase in smear, above zero-error smear that results when a mission-constant error is introduced. The individual error terms are root-sum-squared.

6.2.4.4 Mission-Variable Smear Contributors. Mission-variable smear contributors result in smear which is randomly distributed about the sum of the zero-error and mission-constant smears. Smear from mission-variable contributors varies from photograph to photograph during the mission.

Mission-variable smear contributors are: roll, pitch, and yaw attitude and rate errors about the spacecraft coordinates; V/H sensor crab measurement error, which can be expressed as yaw about the V/H sensor axis; V/H sensor measurement error; terrain variability within the frame; and platen drive velocity variations. The roll, pitch, and yaw position errors are assumed to have uniform distributions; roll, pitch, and yaw rates are assumed to have skewed Gaussian distributions; and the remaining contributors are assumed to have Gaussian distributions. The distributions chosen for attitude rates and position errors are based on verbal communications with Boeing attitude-control personnel. Mission-variable smears are calculated as the increase in smear above zero-error smear which results when a mission-variable smear is introduced. The error terms are root-sum-squared.

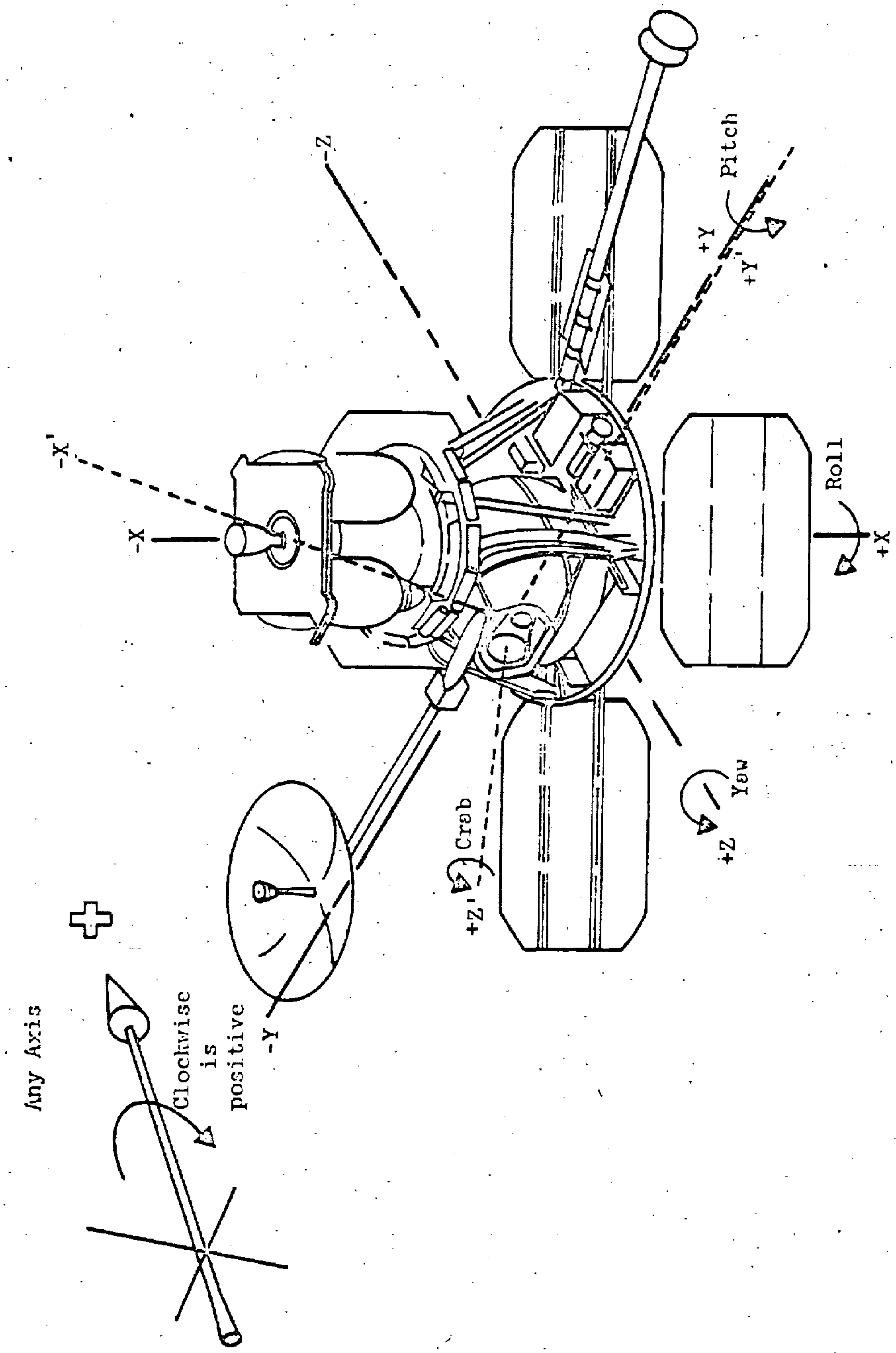



Figure 6-16. Coordinate Systems

6.2.4.5 <u>Summation of Image Smears</u>. Image smears are summed according to the following formula:

$$S = A + \sqrt{\Sigma_i \, b_i^2} + \sqrt{\Sigma_j \, c_j^2}$$

where $S$ = total 3-sigma smear,

$A$ = zero-error smear,

$b_i$ = 3-sigma smear from a mission-constant error,

$c_j$ = 3-sigma smear from a mission-variable error.

Two points must be mentioned in connection with summing smears (1) validity of assuming the independence of the various smear contributors and (2) validity of combining the errors or smears where amplitude distribution is not normal, and in fact can be uniform.

As an example of contributor independence, the smear contributions from a roll rate and yaw rate are determined independently, then combined statistically to give total smear for both a roll rate and a yaw rate. However, the orientation of the PS optical axis with respect to the spacecraft is such that these rates are not independent. Treating these contributors

as being independent results in smear magnitudes which are generally greater than if they were treated as dependent variables. The results are therefore conservative; in addition, the errors introduced are small.

The validity of root-sum-squaring a 3-sigma smear from an error contributor with a normal distribution with the 3-sigma smear from an error contributor with a uniform distribution may be questioned. Analysis has shown that the RSS method is valid when the number of contributors is large and when only a few of the contributors do not follow a normal distribution. Smears due to each contributor are given in Table 6-2, 6-3 and 6-4 for both the 24-inch and 80-mm lenses.

### 6.2.5 Operational Considerations

The V/H sensor continuously corrects for changes in image motion during photography. Its effect on the determination of smear magnitudes is discussed in the following paragraphs.

6.2.5.1 <u>V/H Sensor.</u> The V/H sensor operates during photography to determine the correct IMC rate. It scans the ground ahead of the optical axis at a nominal angle of 7.78 degrees from the optical axis. The image velocity is slightly variable with lens field angle (due to the curvature of the lunar surface across the field); the correct IMC rate is therefore calculated for the center of the field only.

The ratio between the image velocity at a 7.78-degree field angle to the image velocity at center of frame for the vehicle at perilune was determined to be 0.9998. Some smear will result at frame positions off-axis, because image-motion rates are not uniform throughout the frame. If the vehicle is not at perilune, there will also be smear in the center of the frame because the ratio of the image velocity at the center of the frame to the image velocity at the V/H sensor position is also dependent on the distance of the vehicle from perilune.

The V/H sensor also provides an output proportional to vehicle crab. The output is continuously furnished to the S/C attitude control system to reduce yaw position errors. Because the V/H sensor is "looking" ahead of the optical axis there will be some error in yaw correction. Further, the spacecraft yaws about the Z axis in response to a crab angle which is referenced to the optical axis. The optical axis is inclined at an angle of 20 degrees to the spacecraft Z axis. In addition, the V/H crab output is proportional to the combination of roll, pitch, and yaw position and rate errors. The only correction possible is a yaw maneuver by the spacecraft; therefore there will be some residual smear after correction for crab. The performance of the yaw maneuver is assumed to have no effect in reducing the smear which result from attitude rates. Rates are considered as changing rapidly with respect to the V/H sensor time constant. Therefore, the V/H sensor will not have time to correct or supply a correction signal to compensate for these errors.

# TABLE 6-2
## SMEAR BUDGET

TABLE 6-3
SMEAR BUDGET

[illegible]

# TABLE 6-4
## SMEAR BUDGET

[illegible]

6.2.5.2 <u>Inclination Between Photo Subsystem and Spacecraft Coordinates.</u> The optical coordinate system is rotated 20 degrees about the common Y axis (see Figure 6-16). Smear calculations are affected because attitude position and rate tolerances are referred to the spacecraft axes. A single yaw about the spacecraft axis is seen by the photographic subsystem as a combination of roll, pitch, and yaw. Pitch errors are common to both coordinate systems; therefore, a yaw of the spacecraft results in an X-component of smear on the axis of the lens. The same is true for a roll about the spacecraft axis. This component would not occur is the yaw or roll were about the photo subsystem optical axis.

6.2.5.3 <u>Vehicle Position.</u> The spacecraft is oriented in inertial space and does not pitch over as it orbits the moon. Therefore the optical axis will be aligned with the local vertical only during part of a picture taking sequence. The calculations in this section assume that alignment with the local vertical occurs at perilune. As the sketch below shows, this results in a pitch error before and after the vehicle is at the midpoint of a photographic sequence.

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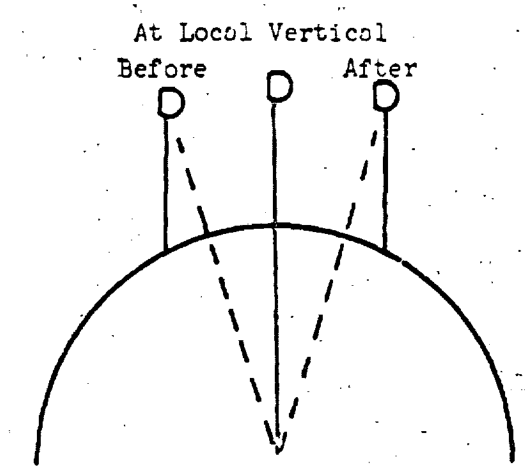


Pitch Errors Before and After Vehicle
Arrives at Local Vertical

a. Photography Spaced About Perilune. In the case of high-resolution photography, the pitch error will be approximately 0.88 degree at the beginning and at the end of a 16-frame, high-rate photographic sequence, provided that photography is spaced symmetrically about perilune. The average smear will be greater at the beginning and end of the photographic sequence than when the vehicle is at the local vertical.

b. Photography Away from Perilune. Certain coverage modes require that photographs be taken some distance from perilune. If this occurs, substantial pitch errors, and consequently, large image smears will result. In Paragraph 6.3, total smear is shown as a function of lens field angle for several values of angular advance from perigee, for a 46 km perilune, 1850 km apolune orbit. Note: These are $2\sigma$ smears, rather than $3\sigma$ as given in the tables (so that the curves can be used in paragraph 6.3 to predict the performance of the system).

6.2.5.4 Smear Due to Off-Nominal Conditions.

a. Image Smear vs Crab Angle Error. Image smear also varies with crab angle error. In paragraph 6.3 a number of curves are presented which relate total smear vs lens field angle for a wide range of crab angle errors and distances from perilune.

b. Image Smear Without IMC. For photography at a perilune of 46 km, image smear without IMC will be approximately 960 microns. A smear of this magnitude will limit resolution to approximately 1/2 line/mm. The importance of IMC is thus demonstrated.

6.2.6 Summary

A number of studies show that the majority of photographs will be taken at an exposure time of 1/25 second. The tables included in this section are therefore valid for an exposure time of 1/25 second; however the data can be converted to 1/50- or 1/100-second exposure times by dividing the 1/25-second smears by 2 or 4, respectively.

The next portion of Section 6 (paragraph 6.3) is concerned with the optical performance of the 24-inch and 80mm lenses. In paragraph 6.3, the smear data presented in this section will be combined with the resolution data to predict the optical performance of the system. However, the 3-sigma smears presented here will be converted to 2-sigma values to predict optical performance (thus, 19 of 20 frames, or 95 percent, will have smear equal to or less than the 2-sigma values. 3-Sigma smear levels result in excessively conservative performance predictions).

## 6.3 OPTICAL PERFORMANCE

Paragraphs 6.1 and 6.2 were concerned with lens/film resolution and the degradation resulting from image smear during the exposure. In this paragraph, the methods described in 6.1 and 6.2 will be integrated to predict the performance of the PS lenses in their operational environment. The smear values used here are 2$\sigma$ values, for 1/25 second exposure time. To convert them to 1/50 or 1/100 second exposure times these smear values can be divided by 2 or 4 respectively.

The MTF of the 24-inch lens, as described previously, was calculated using ray tracing techniques. The MTF's were calculated both on- and off-axis, as were the smear levels which are expected to be encountered. The lens/smear MTF's and the SO-243 AIM curve were used to predict optical performance over a range of operating conditions. Note: The resolution predictions of this paragraph are valid for 2$\sigma$ smears only. The information is presented graphically; the following table lists the number of each graph and describes the curves.

| Graph No. | Curves |
|---|---|
| 6-17 | Static Resolution vs Contrast for Several Peak Resolutions (reproduced from Section 6.1) |
| 6-18 | Static Resolution vs Lens Field Angle for Several Peak Resolutions. |
| 6-19 through 6-24 | Smear vs Lens Field Angle for Nominal Smear Contributors and a range of crab angle errors and distances from perilune. |
| 6-25 | Dynamic Resolution vs Smear for Several Peak Static Resolutions |

These curves are used in the following manner:

a. Determine the on-axis, static, 3:1 contrast resolution measured in testing (for example, 120 lines/millimeter) for any particular lens.

b. Select a contrast ratio (for example, 4:1).

c. Go to curve 6-17. Using the curve labeled 120 lines/millimeter at 3:1, read off 132 lines/millimeter at 4:1 contrast.

d. Go to curve 6-18. Select a lens field angle (for example, 5 degrees). For 132 lines/millimeter on-axis resolution, read off 133 lines/millimeter Y-resolution and 71 lines/millimeter X-resolution at 5° field angle.

e. Go to curve 6-19, if nominal smear contributors are desired (or 6-20 thru 24 if crab or pitch errors must be analyzed). At 5 degrees lens field angle, and at the selected distance from perilune (0.0 degrees) read off Y-smear equal to 5.6 microns, and X-smear equal to 9 microns.

f. Go to curve 6-25. For 71 and 133 lines/millimeter X- and Y-static resolution (step 4) and 9 and 5.6 microns of smear respectively, read off dynamic resolution of:

   57 lines/mm X-resolution
   94 lines/mm Y-resolution

The values obtained are summarized as follows:

> For a lens measured at 120 lines/millimeter on-axis at 3:1 contrast during testing, a dynamic resolution of 94 lines/millimeter Y-direction, and 57 lines/millimeter X-direction will be obtained in orbit if:
>
> Contrast ratio = 4:1
> Lens Field Angle = 5 degrees
> Angular advance from perilune = 0.0 degrees
> Smear contributors are $2\sigma$ nominal values.

X- and Y-resolution predictions are often combined for convenience by taking the geometric mean of the two values (that is, the square root of the product). For this example, a geometric mean resolution of 73 lines/millimeter results.

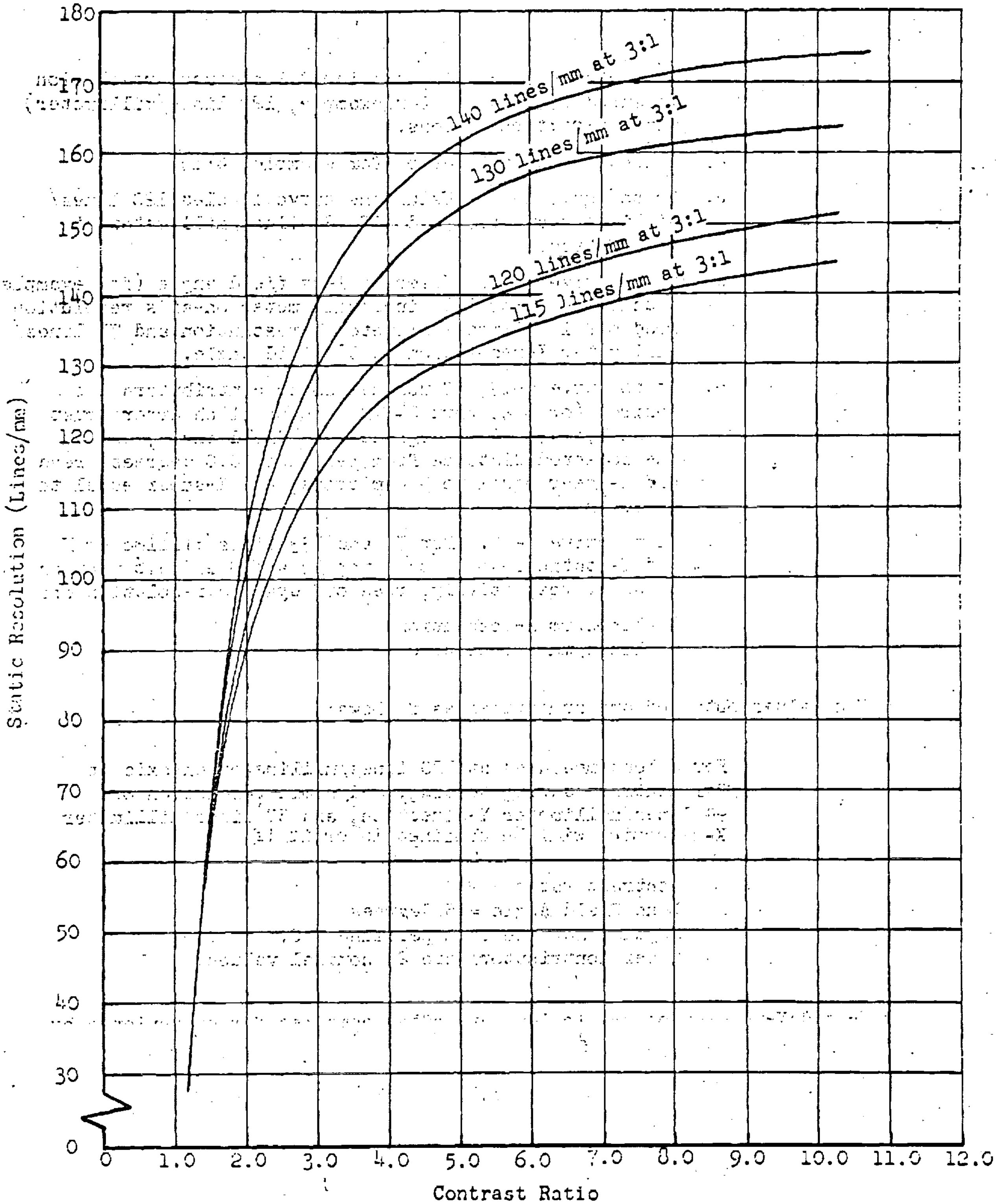


Figure 6-17. Resolution vs Contrast for 24-Inch Lens, For Several Peak Lens Resolution Values.

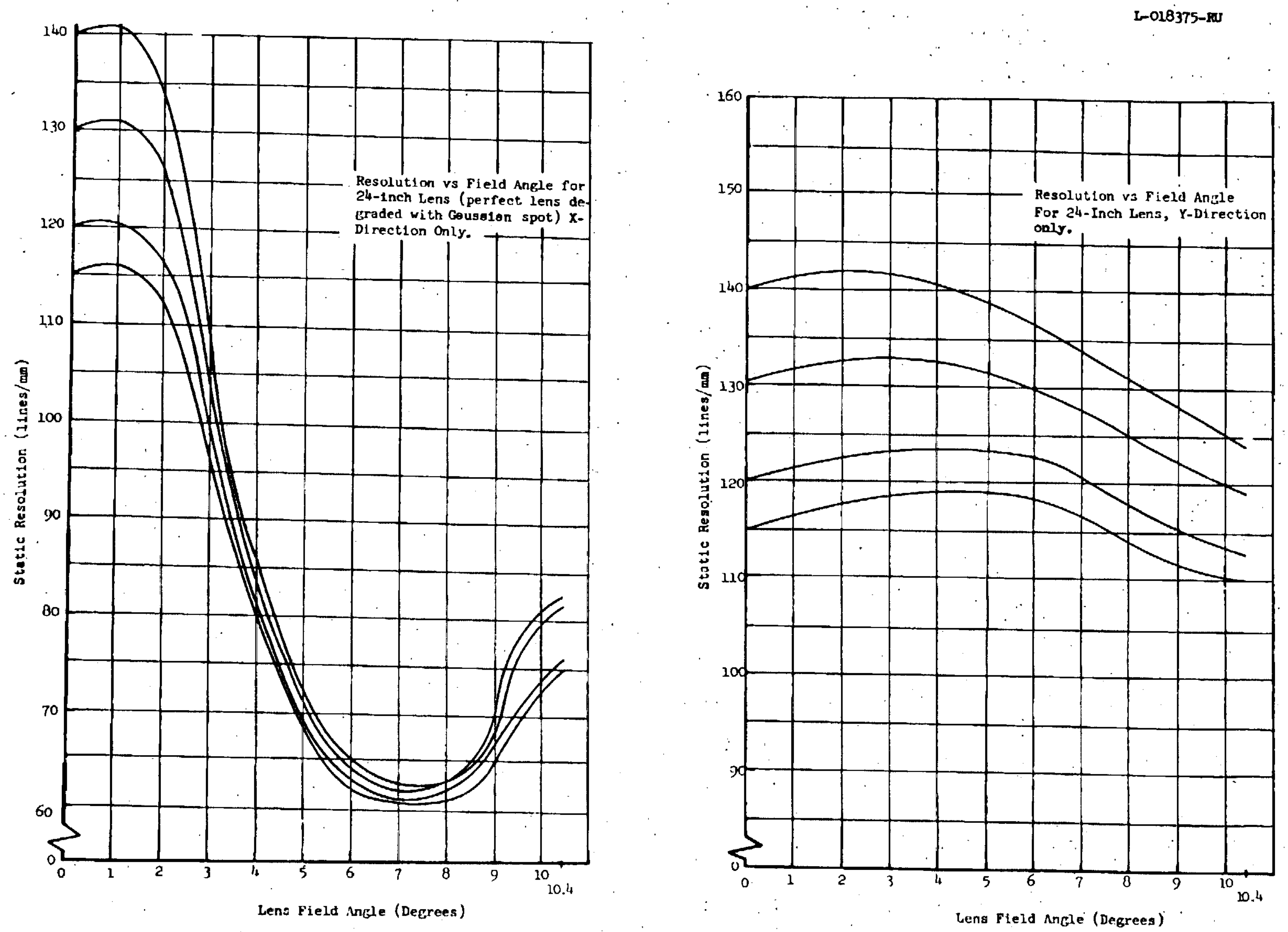


Figure 6-18. Static Resolution vs Lens Field Angle

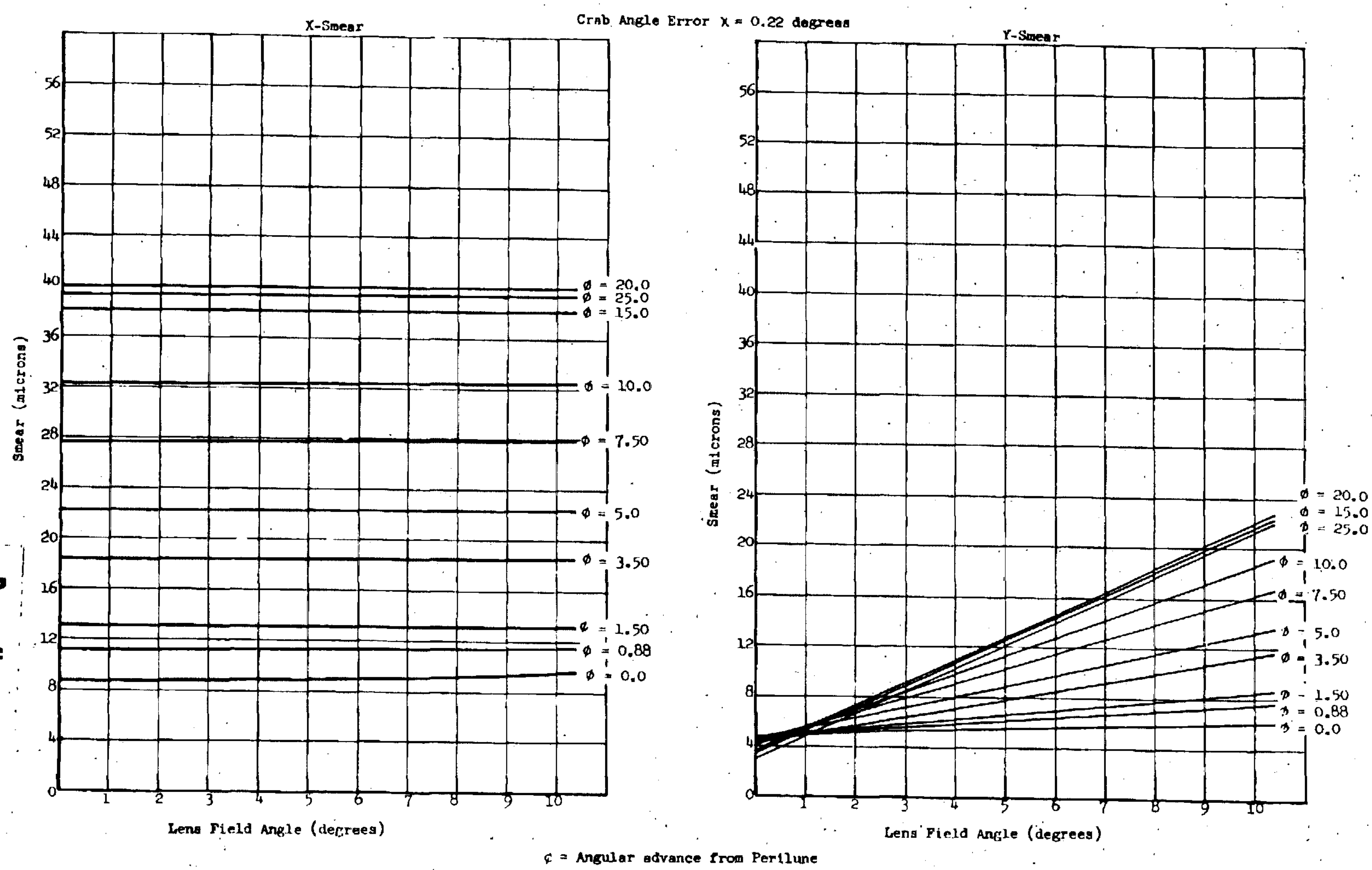


Figure 6-19. Smear vs Lens Field Angle. Nominal $2\sigma$ Smear Contributors for Several Angular Advances from Perilune.

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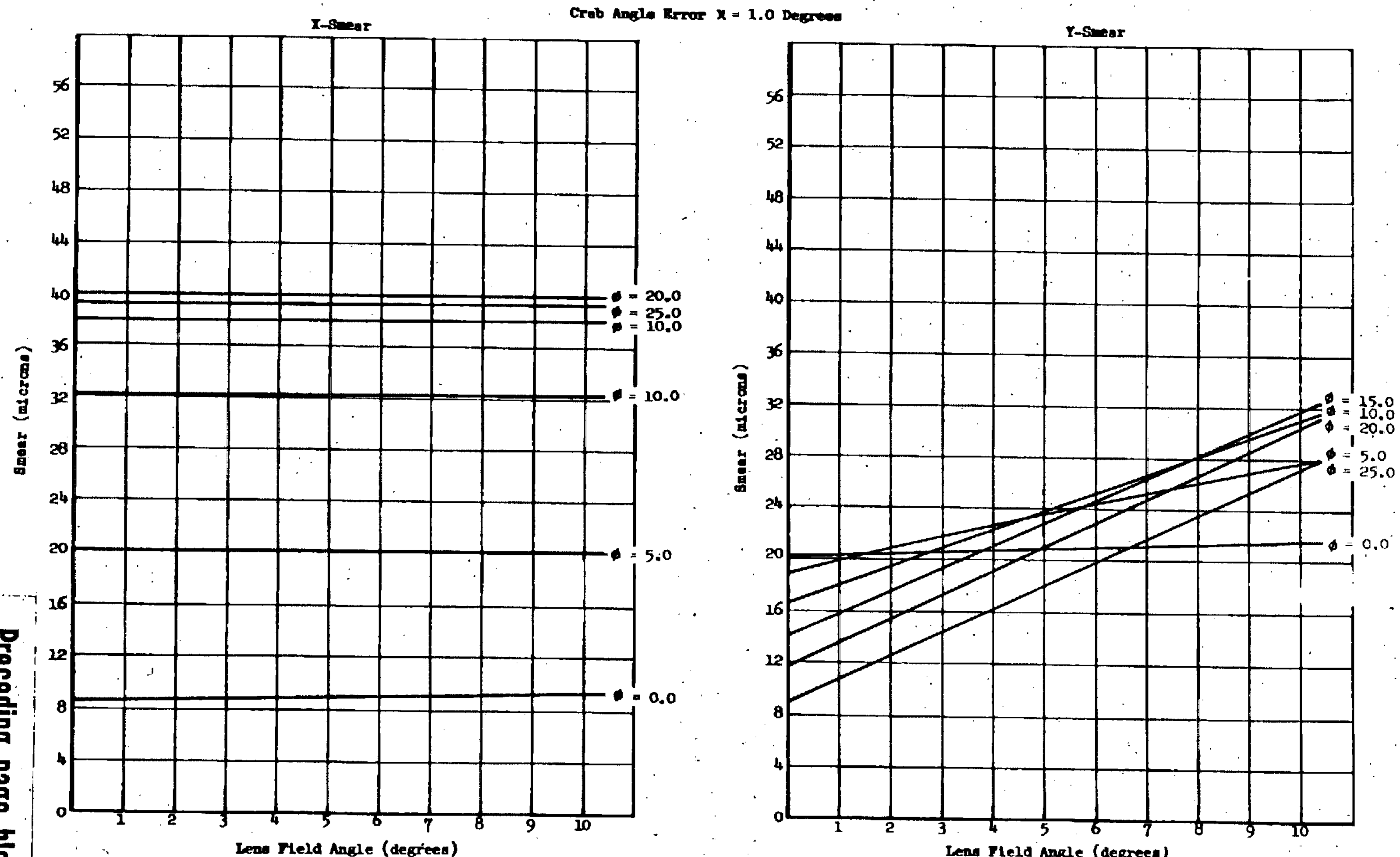
Crab Angle Error X = 1.0 Degrees




φ = Angular Advance From Perilune

Figure 6-20. Smear vs Lens Field Angle. For 2σ Smear Contributors With a Constant 1.0 Degree Crab Angle Error for Several Angular Advances from Perilune.

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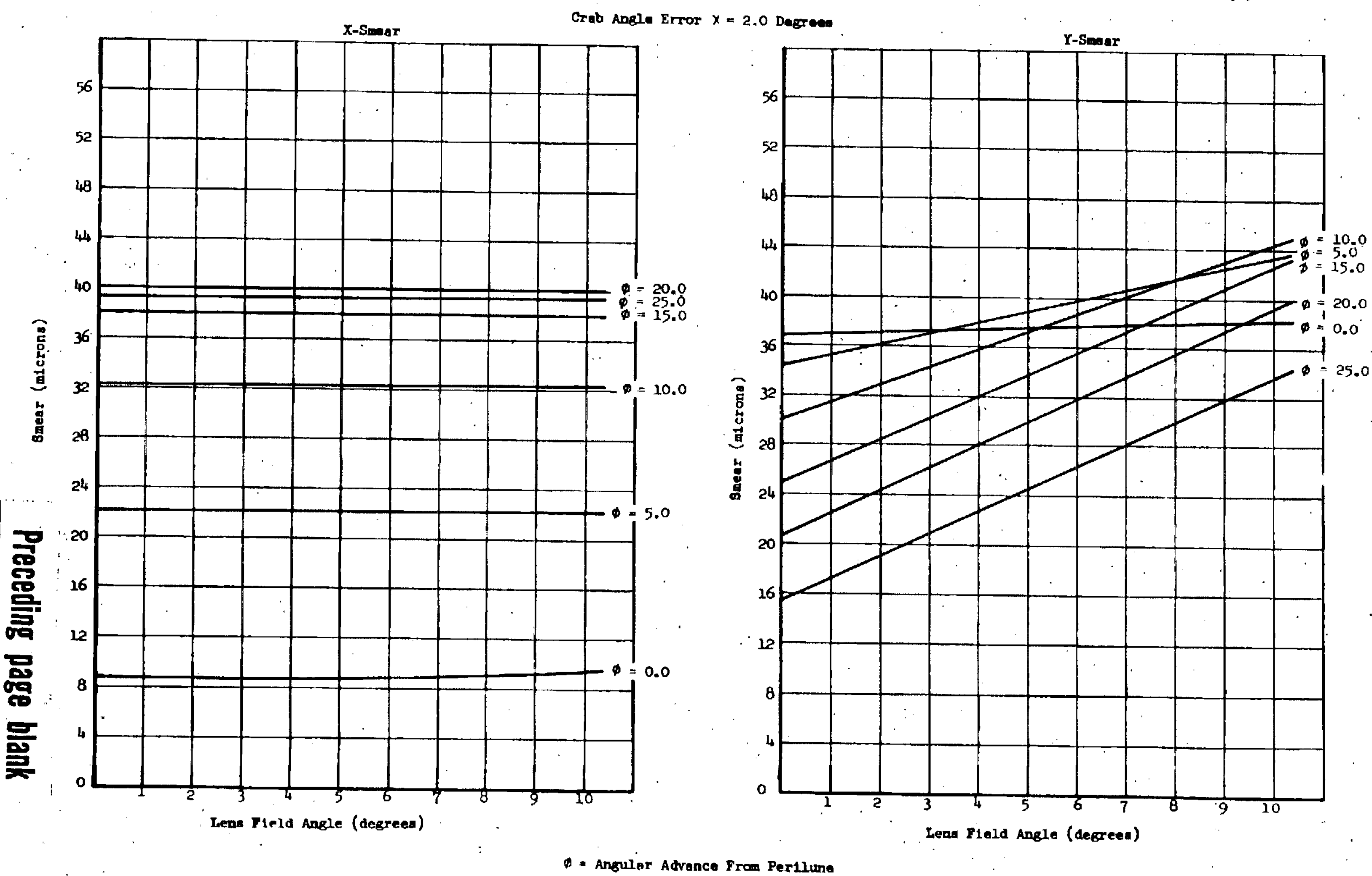


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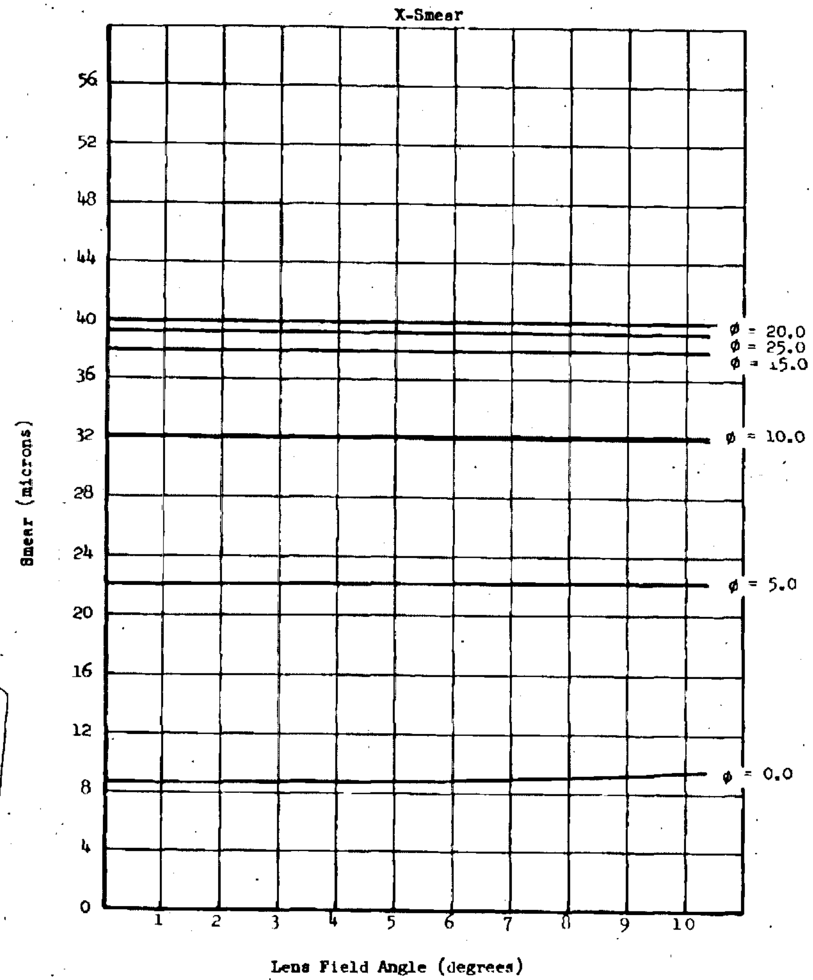
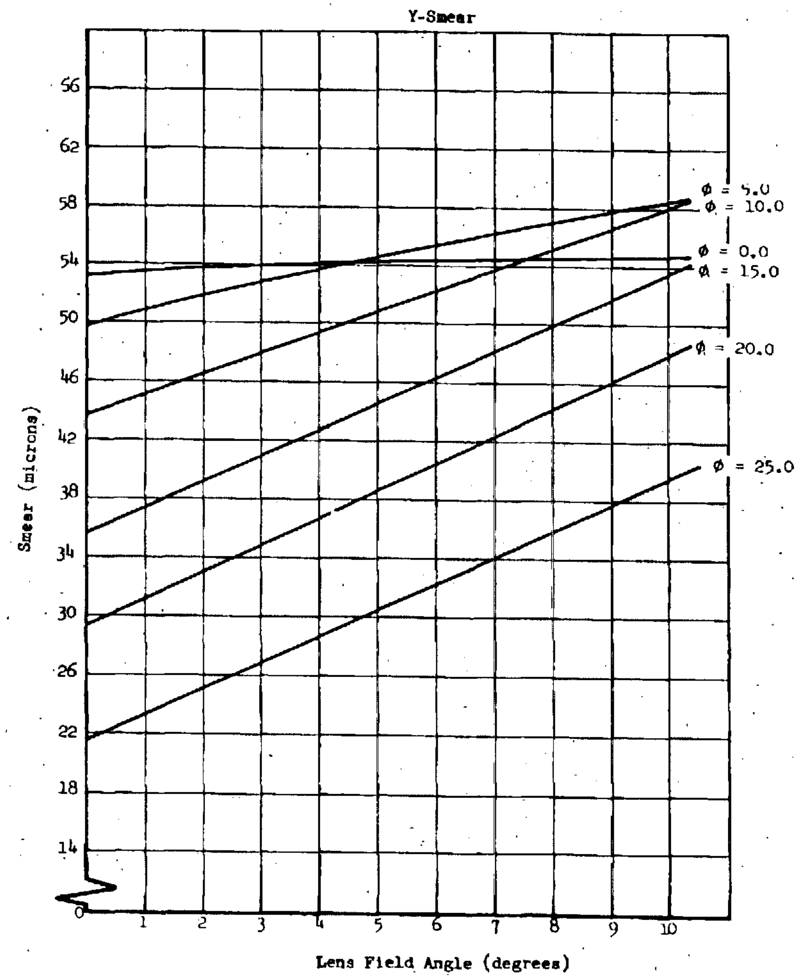
Figure 6–21. Smear vs Lens Field Angle. For 2σ Smear Contributors With A Constant 2 degree Crab Angle Error for Several Angular Advances from Perilune.

Crab Angle Error χ = 3.0 Degrees




ϕ = Angular Advance From Perilune

Figure 6-22. Smear vs Lens Field Angle. For 2σ Smear Contributors With a Constant 3 Degree Crab Angle Error for Several Angular Advances from Perilune.

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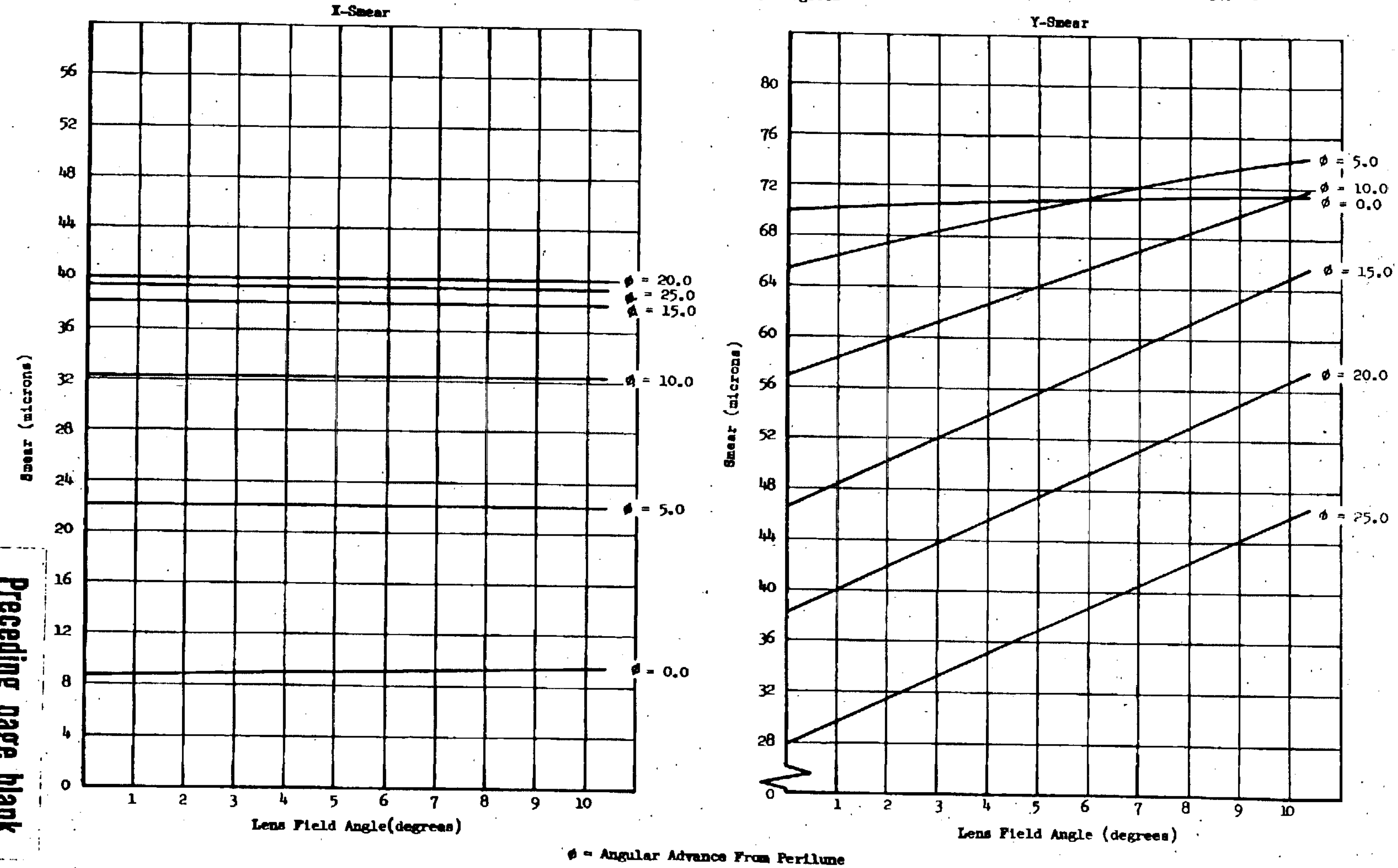


Figure 6-23. Smear vs Lens Field Angle. For 2σ Smear Contributors With a Constant 4 Degree Crab Angle Error for Several Angular Advances from Perilume.

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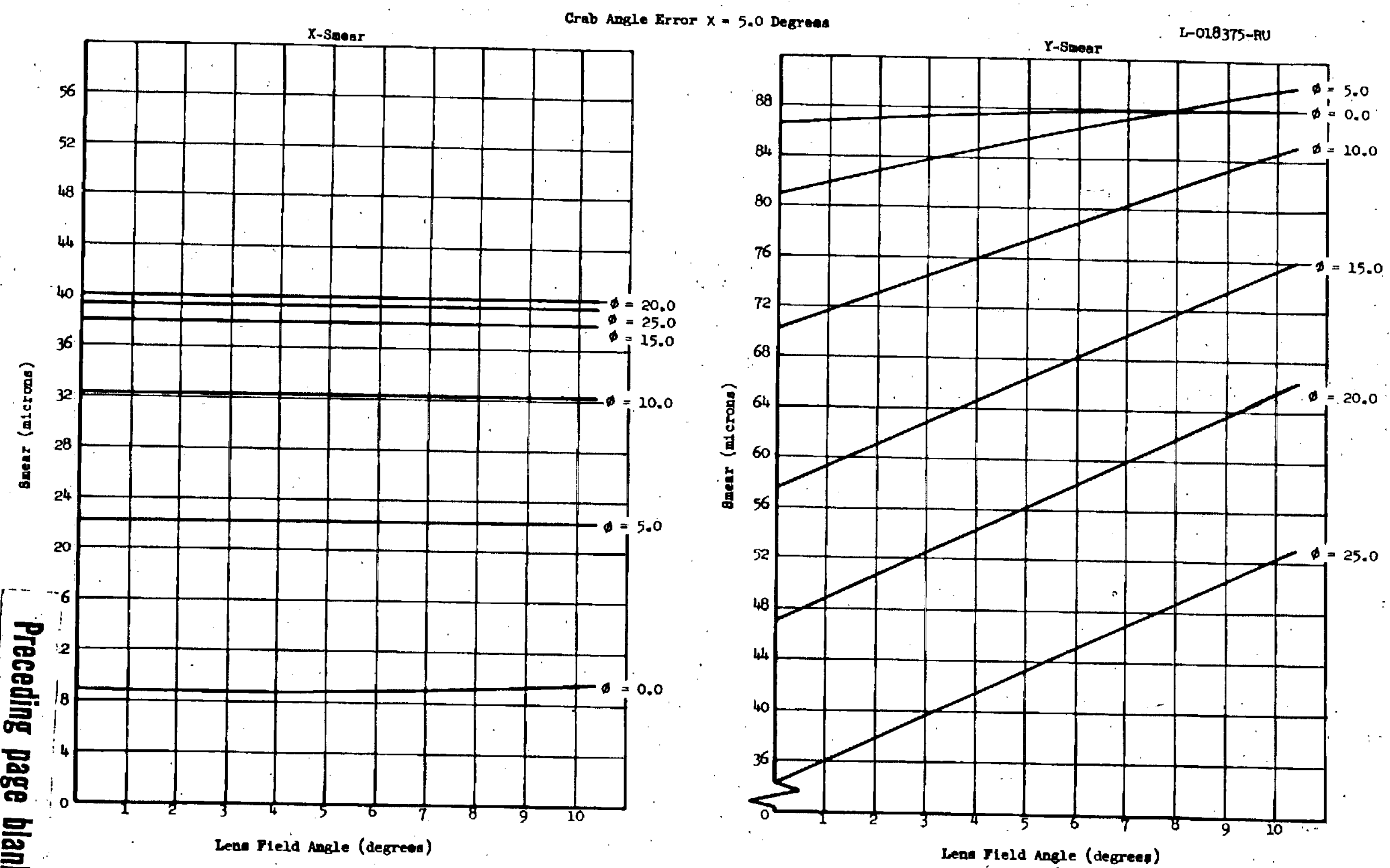


ϕ = Angular Advance From Perilune

Figure 6-24. Smear vs Lens Field Angle. For 2σ Smear Contributors With a Constant 5 Degree Crab Angle Error for Several Angular Advances from Perilune.

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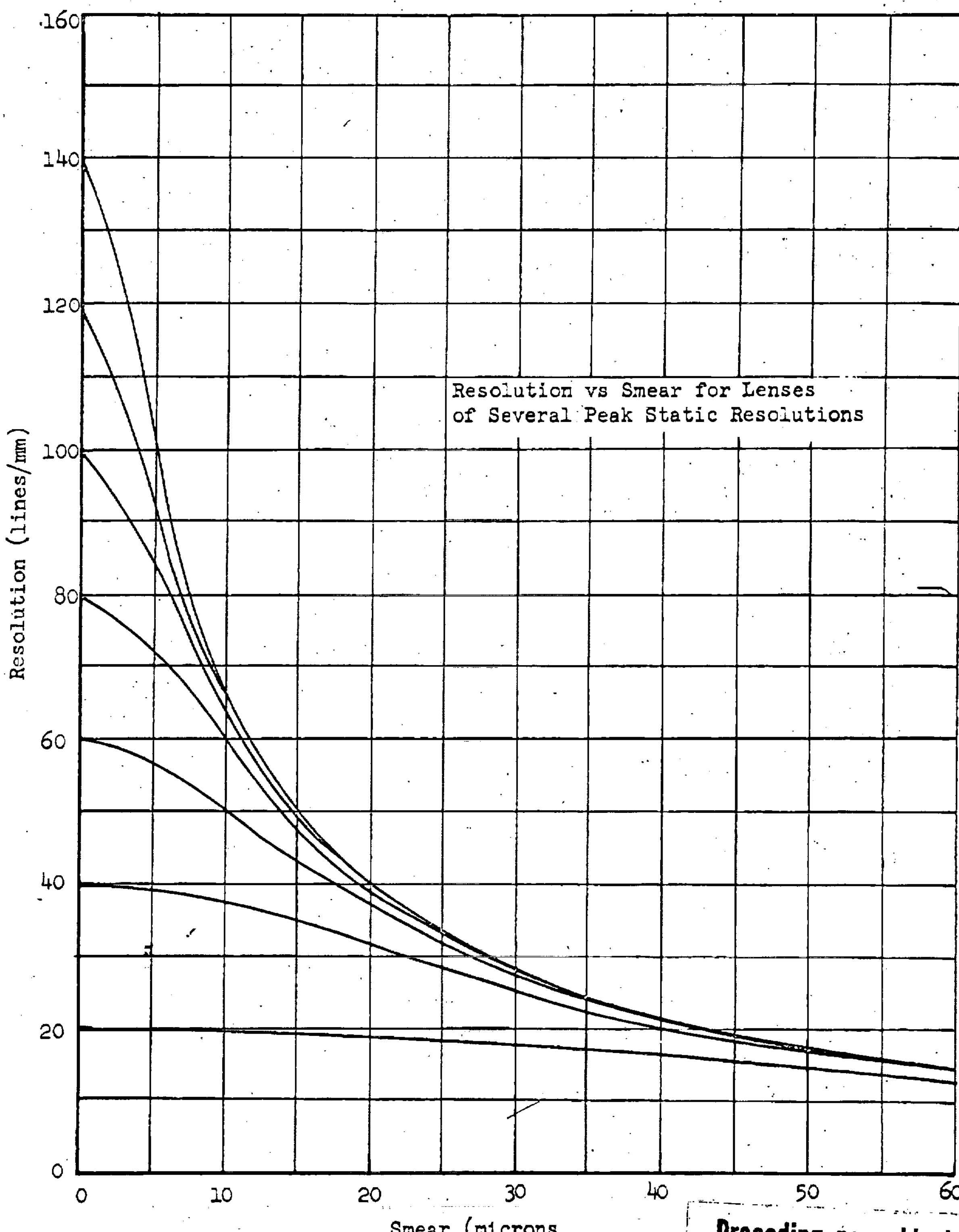


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Figure 6-25. Resolution vs Smear

For convenience, the process described above has been done for a range of contrasts, distances from perilune, and nominal, 2σ smear values, in Figures 6-26 through 6-29.

To convert the lens/smear/film resolution in lines/millimeter to resolution in meters on the ground, Figure 6-30 can be used. To use this Figure, a lens/smear/film resolution is first obtained as described previously. The altitude is then determined, and the ground resolution read-off in Figure 6-30.

### 6.3.1 80-mm Lens Optical Performance

The procedure described in the preceding paragraphs for the 24-inch lens is followed exactly for the 80-mm lens. The curves to be used for this system are Figures 6-31 through 6-34. Smear vs Field Angle Data can be obtained from Tables 6-3 and 6-4.

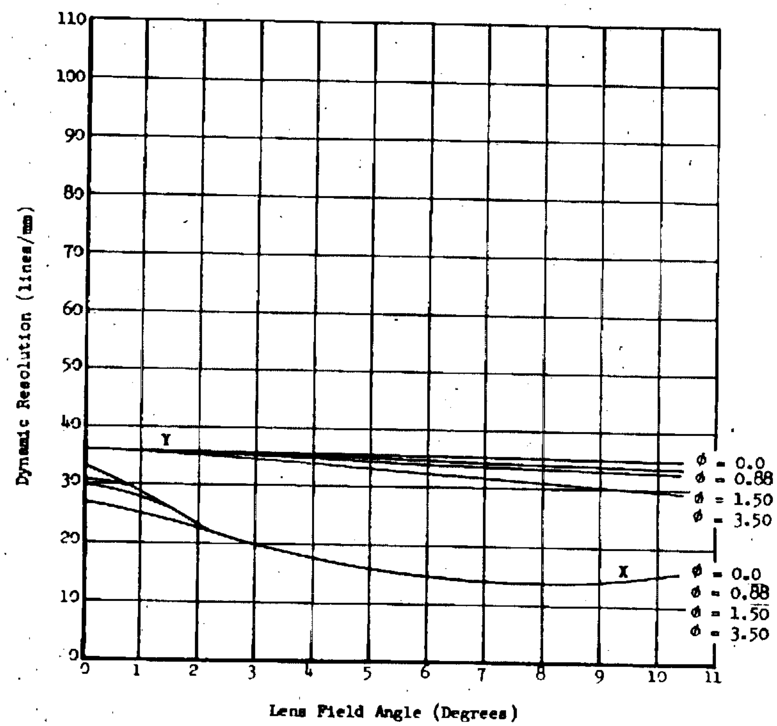
### 6.3.2 Summary

The data presented in this section can be used to determine the ability of the PS to resolve tri-bar-like targets on the moon. Because the majority of detail in a lunar scene consists of craters, the next paragraph presents data which can be used to relate tri-bar ground resolution to the minimum resolvable crater size. In the analysis, craters are approximated by concave cones of various sizes and depths.

## 6.4 CONE RESOLUTION

To arrive at a useful compromise for specifying lunar surface resolution, an equivalence was established between concave cones of various sizes and depths (which are used to approximate craters) and the normal tri-bar resolution standard.

Contrast = 1.2:1
Static Resolution = 115 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors




Contrast = 1.5:1
Static Resolution = 115 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributor

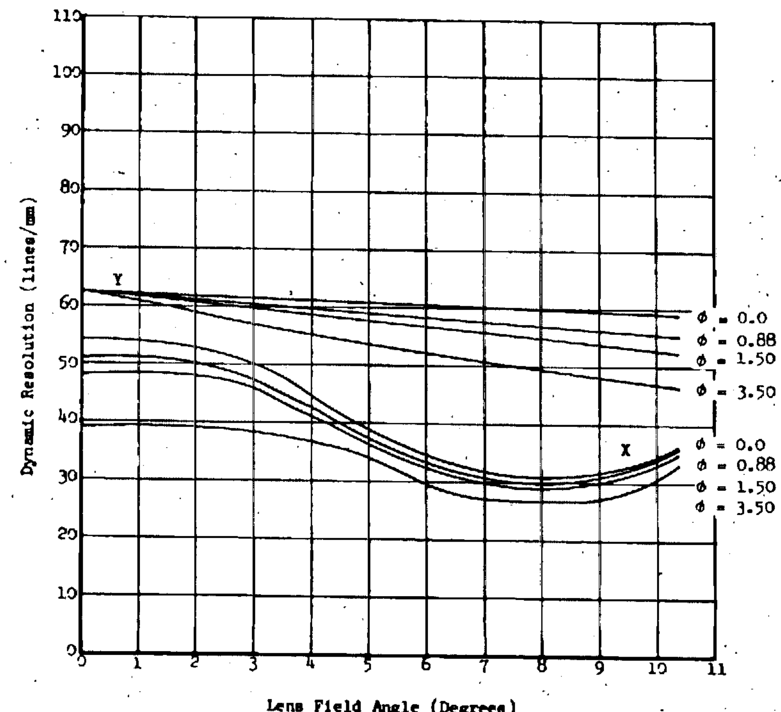
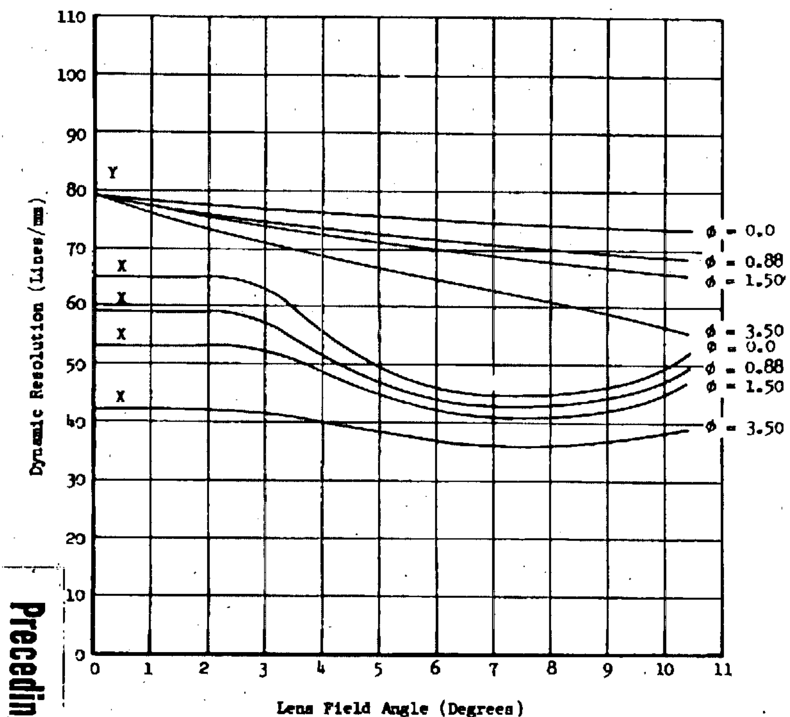



Figure 6-26. Dynamic Resolution vs Lens Field Angle for the 24-Inch Lens, and for Four Angular Advances from Perilune.

Contrast = 2.0:1
Static Resolution = 115 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors




Contrast = 3.0:1
Static Resolution = 115 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors

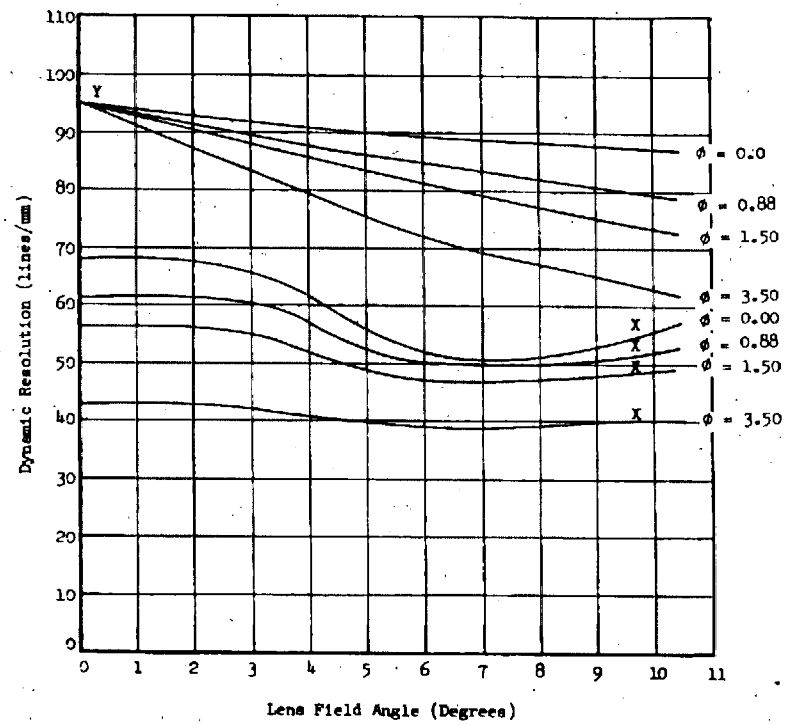



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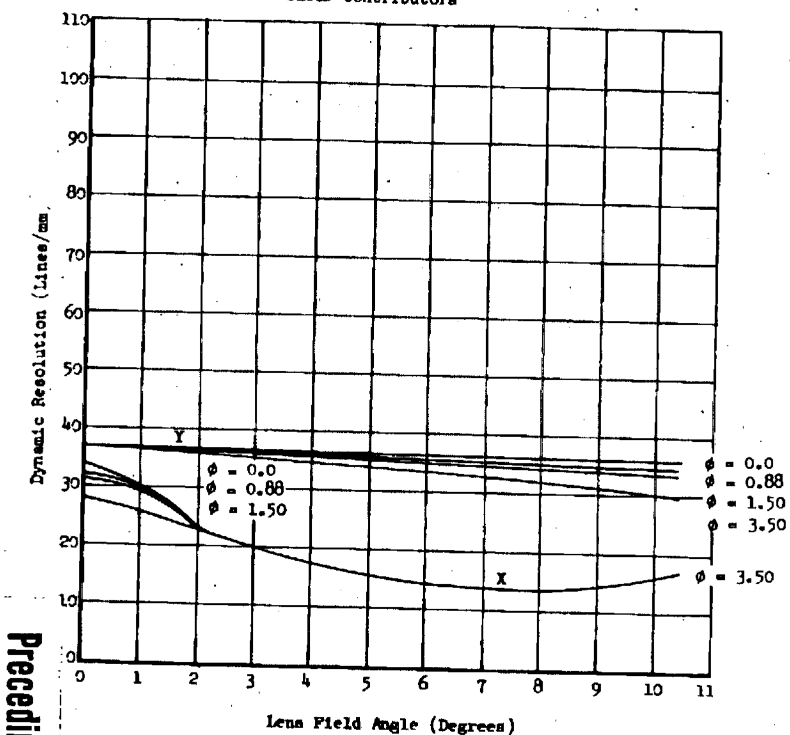
Figure 6-27. Dynamic Resolution vs Lens Field Angle for the 24-Inch Lens, and for Four Angular Advances from Perilune

Contrast = 1.2:1
Static Resolution = 130 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors




Contrast = 1.5:1
Static Resolution = 130 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors

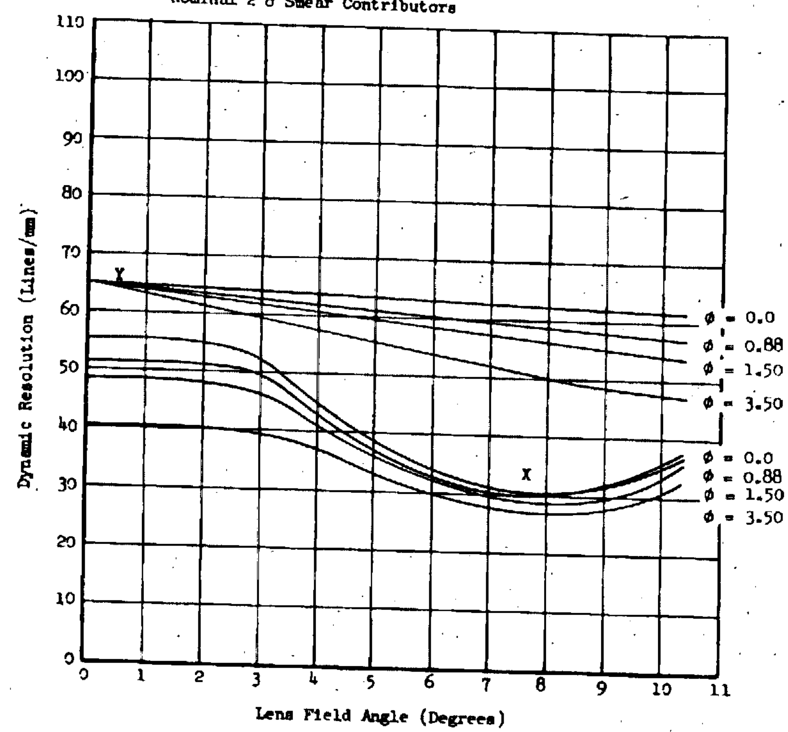



Figure 6-28. Dynamic Resolution vs Lens Field Angle for the 24-Inch Lens, and for Four Angular Advances from Perilune

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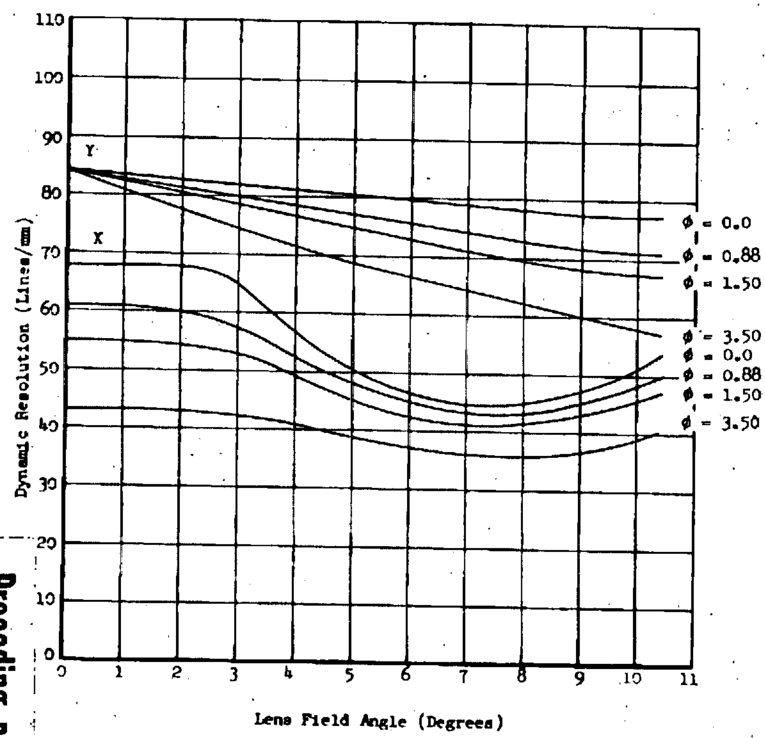
Contrast = 2.0:1
Static Resolution ≈ 130 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors




Contrast = 3.0:1
Static Resolution = 130 lines/mm at 3:1 Contrast
Nominal 2 σ Smear Contributors

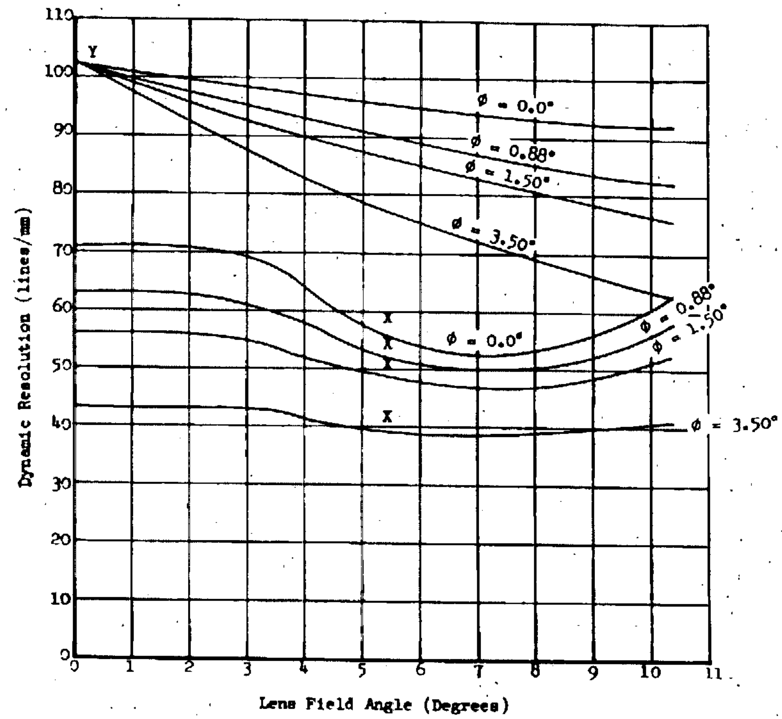



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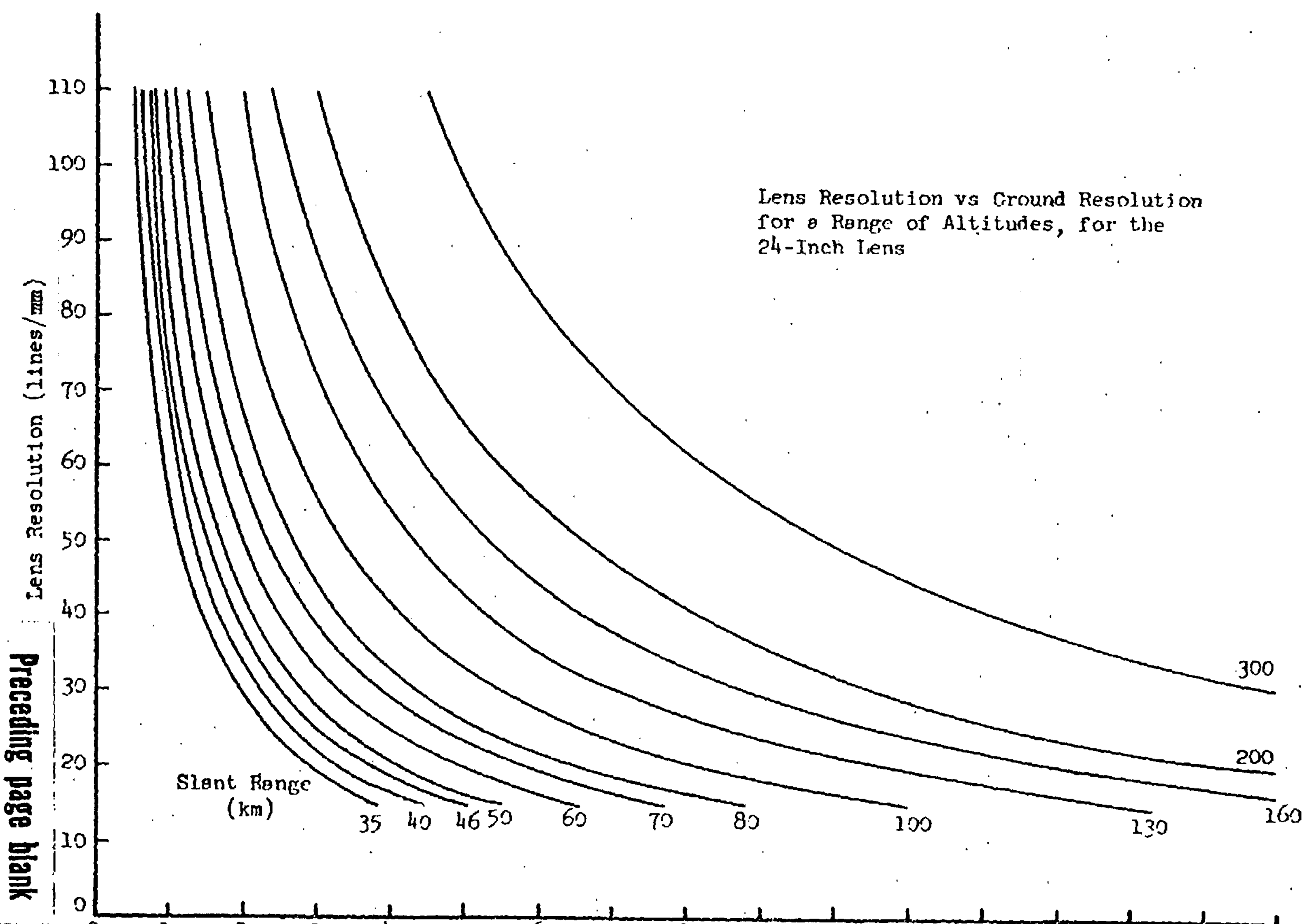
Figure 6-29. Dynamic Resolution vs Lens Field Angle for the 24-Inch Lens, and for Four Angular Advances from Perilune

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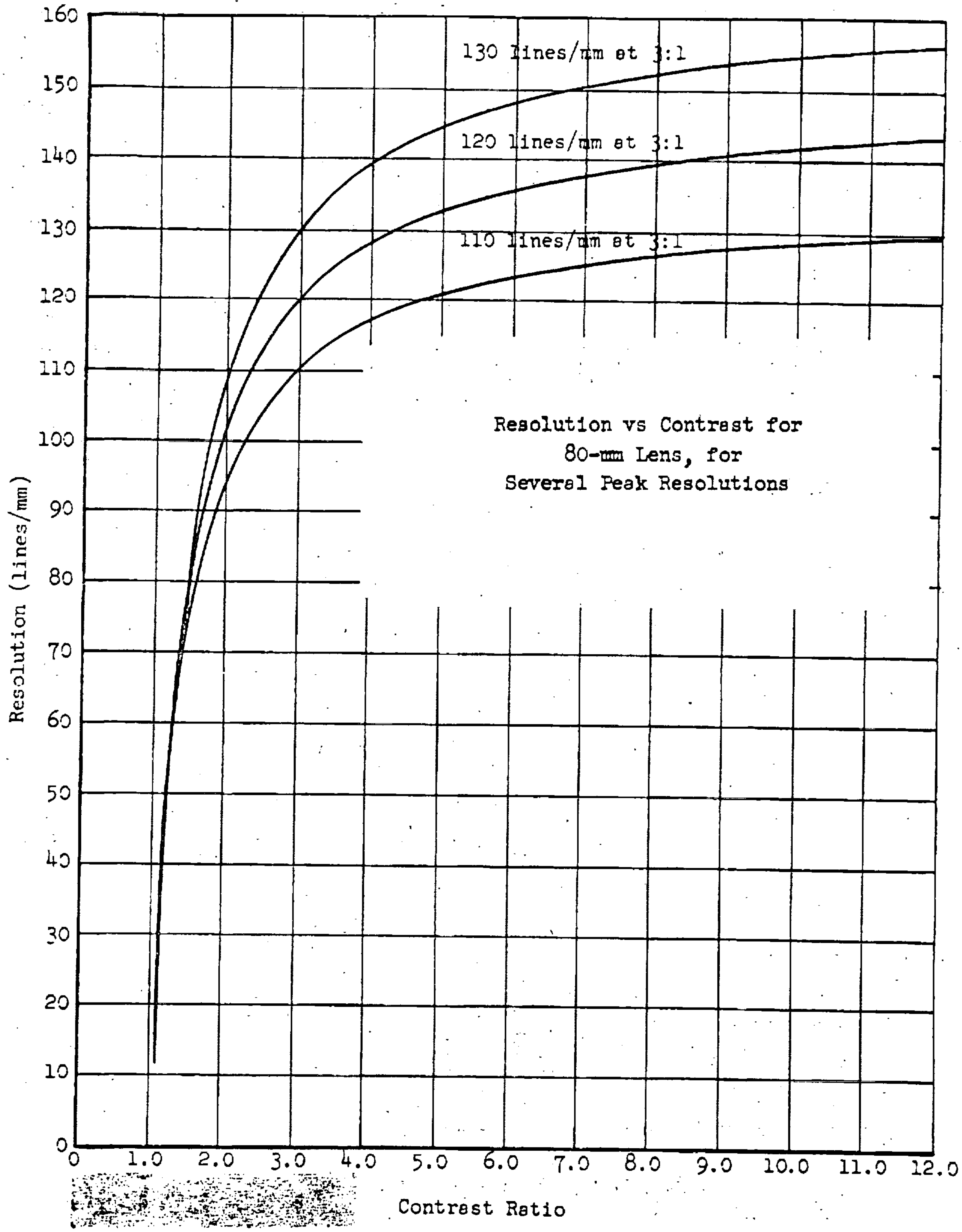



Figure 6-31. Resolution vs Contrast for the 80-mm Lens

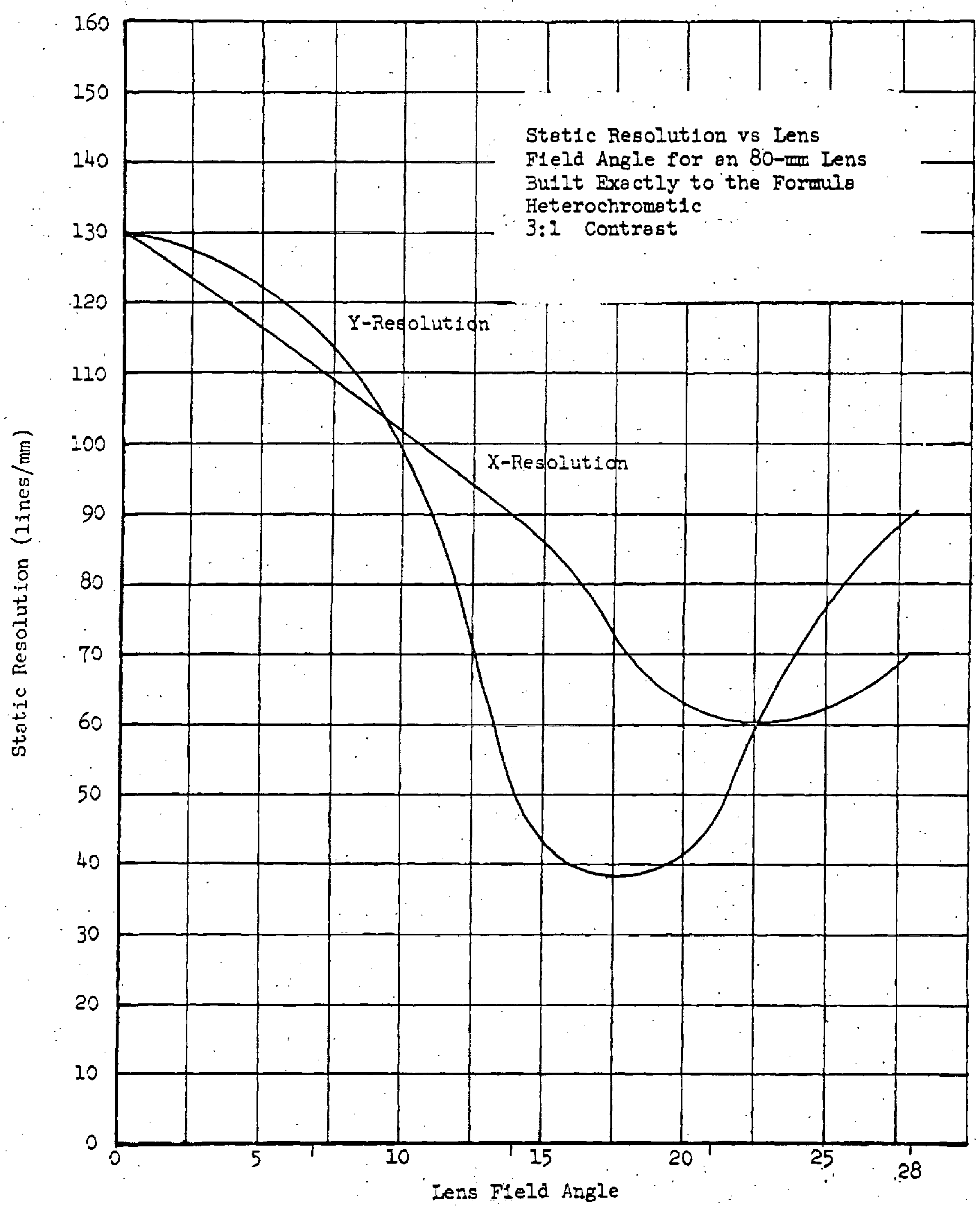



Figure 6-32. Static Resolution vs Lens Field Angle for the 80-mm Lens

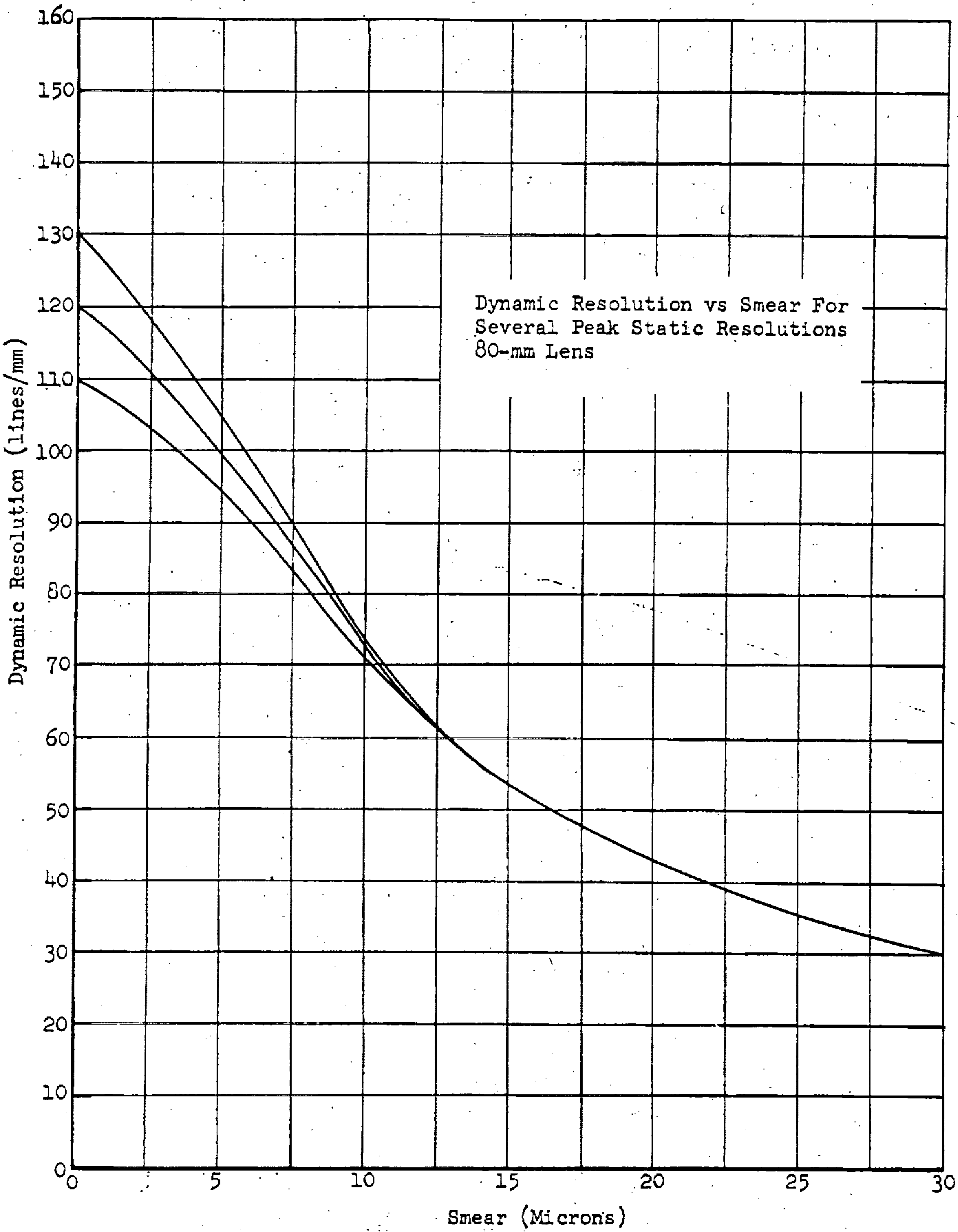
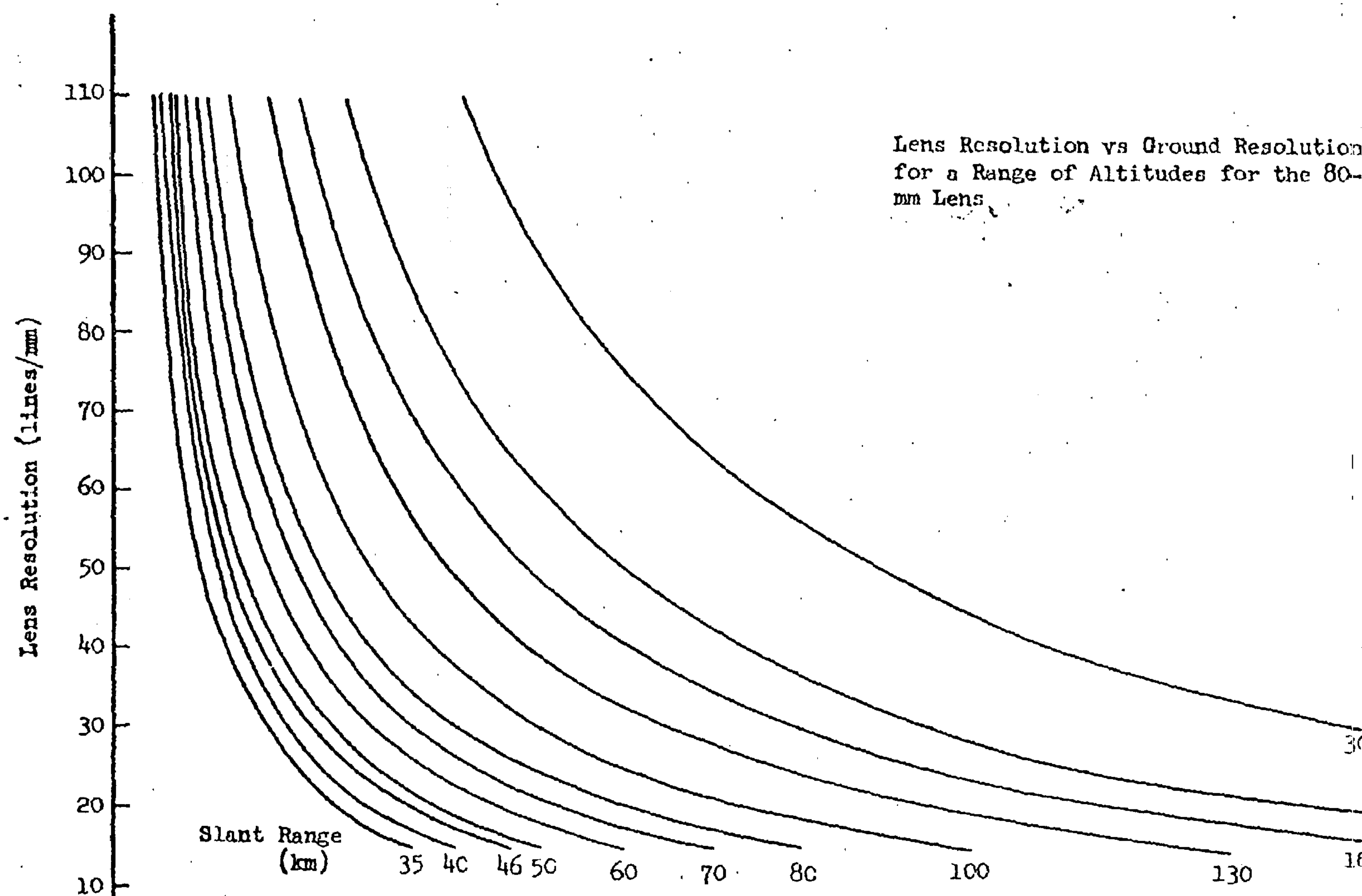



Figure 6-33. Resolution vs Smear for the 80-mm Lens




Lens Resolution vs Ground Resolution for a Range of Altitudes for the 80-mm Lens

The data presented in this section can be used to convert a lens resolution at a given contrast ratio to a resolvable cone diameter and the range of cone depths and solar phase angles over which the cone diameter can be detected. The method used in deriving the equivalence is described in paragraphs 6.4.1.1 and 6.4.2. Section 6.4.3 presents the curves used in obtaining the cone diameter and depth/phase angle range over which the diameter can be detected.

6.4.1 Modulation

The modulation of a tri-bar is defined as

$$m = \frac{B\ max - B\ min}{B\ max + B\ min}$$

As shown in Figure 6-35, this modulation is derived from a square wave intensity distribution. Note also that the length-to-width ratio of tri-bar targets is fixed at 5:1. Modulation is related to contrast by the definition $C = \frac{B\ max}{B\ min}$.

The intensity distribution across a concave conical surface is also shown in Figure 6-35. Analysis of this shape using the Fedoretz Photometric function (see Section 7) for a range of solar phase angles has shown that the intensity profile across the cone is nearly sinusoidal. Thus, when equating tri-bar modulation to cone modulation, two factors must be taken into account:

a. The difference in intensity distribution
b. The difference in length-to-width ratio

6.4.1.1 Intensity Distribution. Cone modulation can be expressed as

$$m = k\,\frac{B\ max - B\ min}{B\ max + B\ min},\ \text{or}\ m_{cone} = k m_{tri\text{-}bar}$$

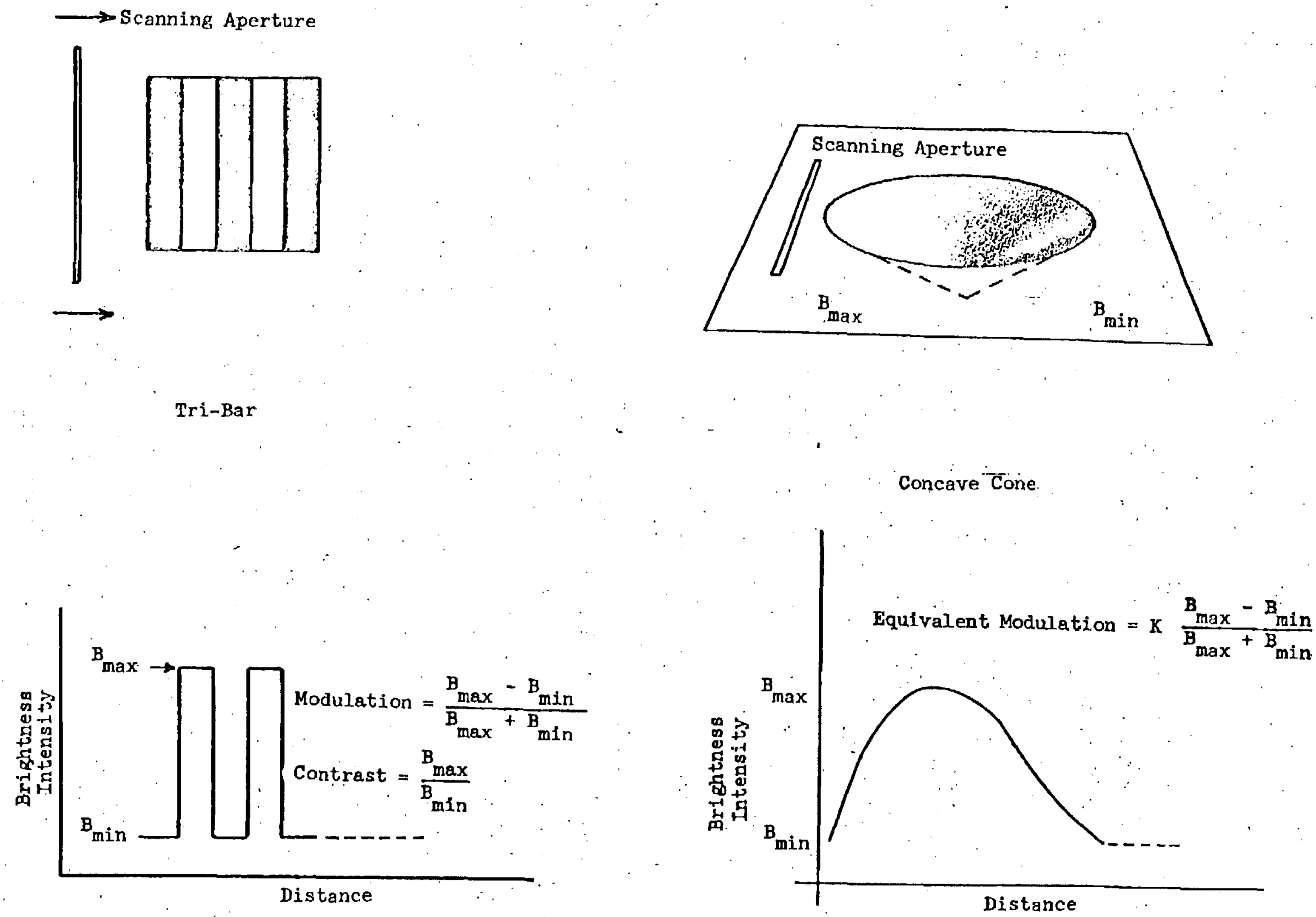



Figure 6-35. Brightness Distribution, Tri-Bars and Concave Cones

where the factor k accounts for the difference in intensity distribution. From extensive analysis and work with lunar surface simulations, the factor k was estimated to be 0.22. Thus, the equivalent cone modulation which is used in deriving the equivalence is 0.22 times the tri-bar modulation.

6.4.1.2 Length-to-Width Ratio. As given above, the length-to-width ratio of a tri-bar target is fixed at 5:1. To account for the difference in shape between tri-bars and cones, the size of a rectangular tri-bar line-space pair is related to the size of a circular cone base. This is done by equating the areas. As shown in Figure 6-36 a square portion of a tri-bar target of pitch a has an area of $(2a)^2 = \frac{\pi D^2}{4}$

$$D = (2a)\sqrt{\frac{4}{\pi}} = (2a)\ 1.13$$

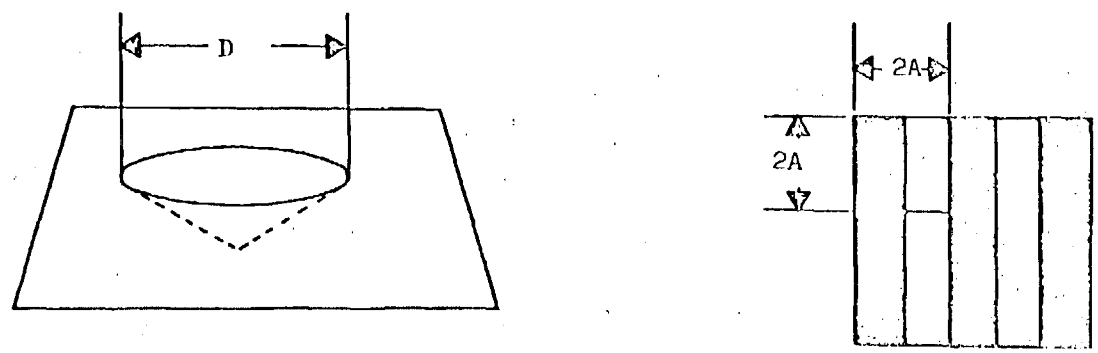
Because the tri-bar resolution is in terms of line-space resolution (distance 2a), the equivalent cone disk diameter can be determined by multiplying tri-bar ground resolution by 1.13. In Figure 6-37, tri-bar lens resolution is plotted vs crater disk diameter for a range of altitudes.

### 6.4.2 Equivalent Tri-Bar Contrast

In Figure 6-38, 6-39, and 6-40, the equivalent tri-bar contrast is calculated as a function of solar phase angle for a range of cone (or crater) sizes and depths, taking into account the photometric function of the surface and the relationship between cone and tri-bar modulation.

### 6.4.3 Ground Resolution

The first step in calculating ground resolution is to determine the relationship between lens tri-bar resolution and resolvable crater disk size (that is, including the factor of 1.13). This relation is plotted in Figure 6-37, for a range of altitudes.



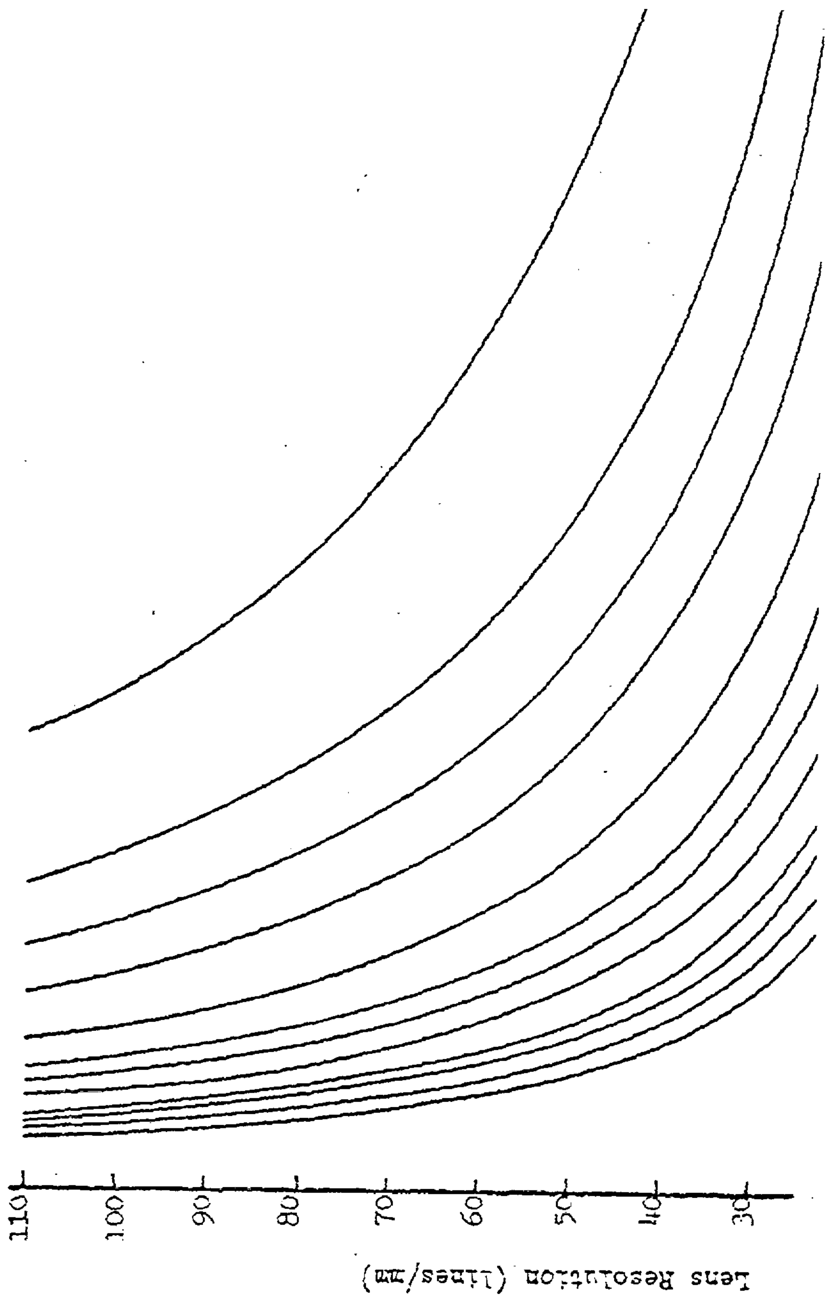

Tri-Bar Resolution =
A lines/mm

Equal Areas:

$$\frac{\pi D^2}{4} = (2A)^2$$

$$D = (2A)\ 1.13$$

Figure 6-36. Derivation of Cone vs Tri-Bar Equivalence


110
100
90
80
70
60
50
40
30
Lens Resolution (lines/mm)

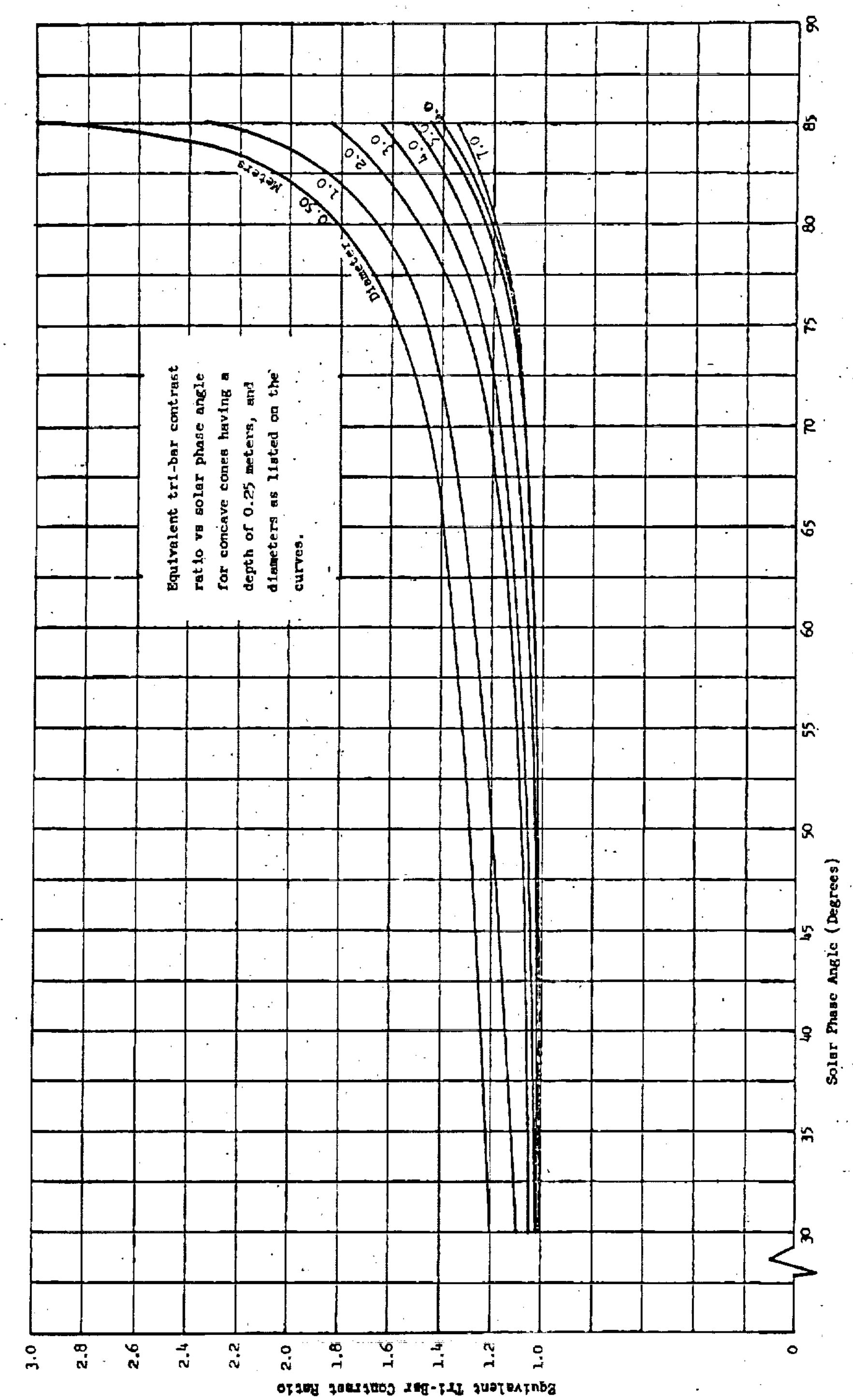



Figure 6-38. Equivalent Tri-Bar Contrast vs Solar Phase Angle

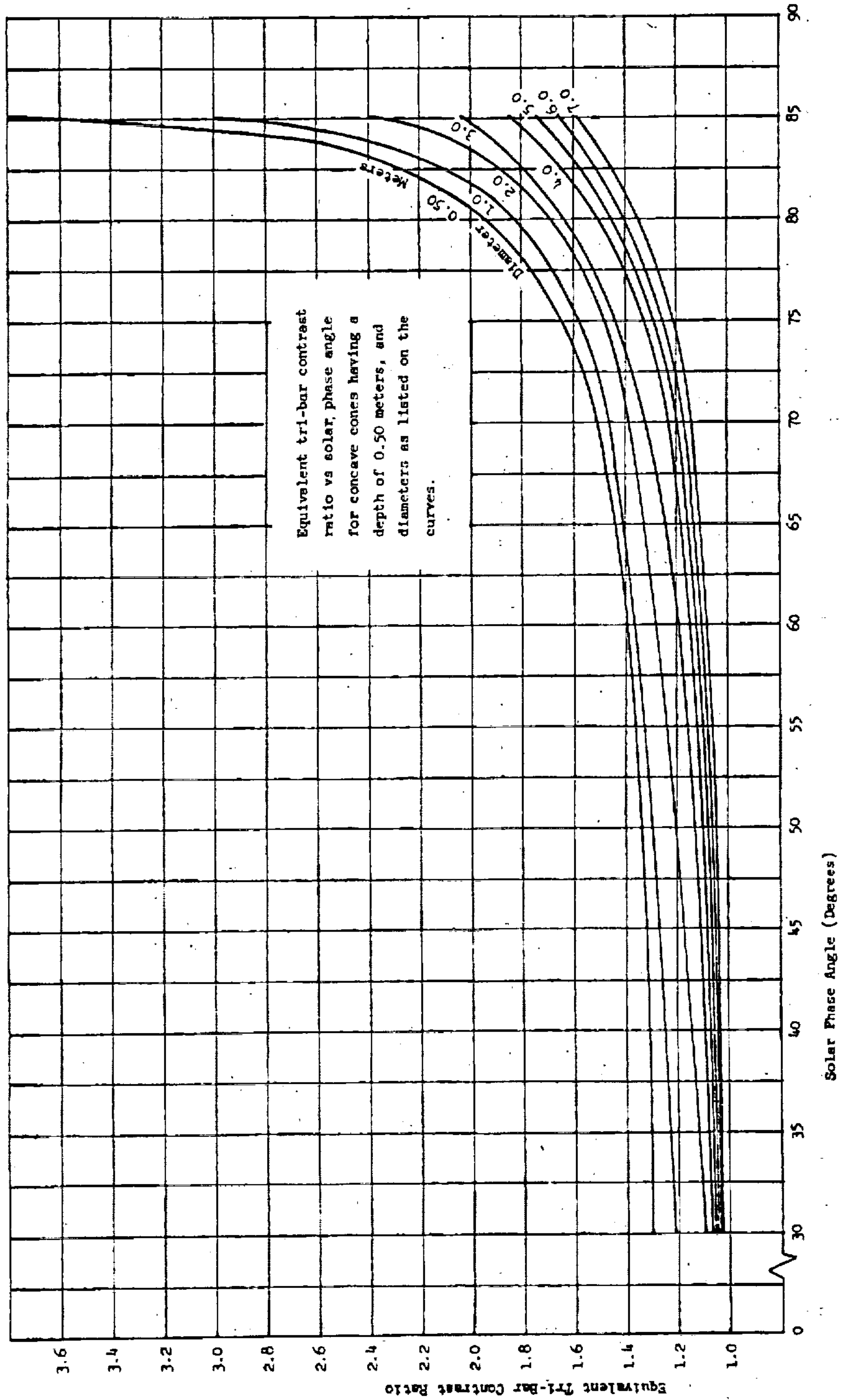



Figure 6-39. Equivalent Tri-Bar Contrast vs Solar Phase Angle

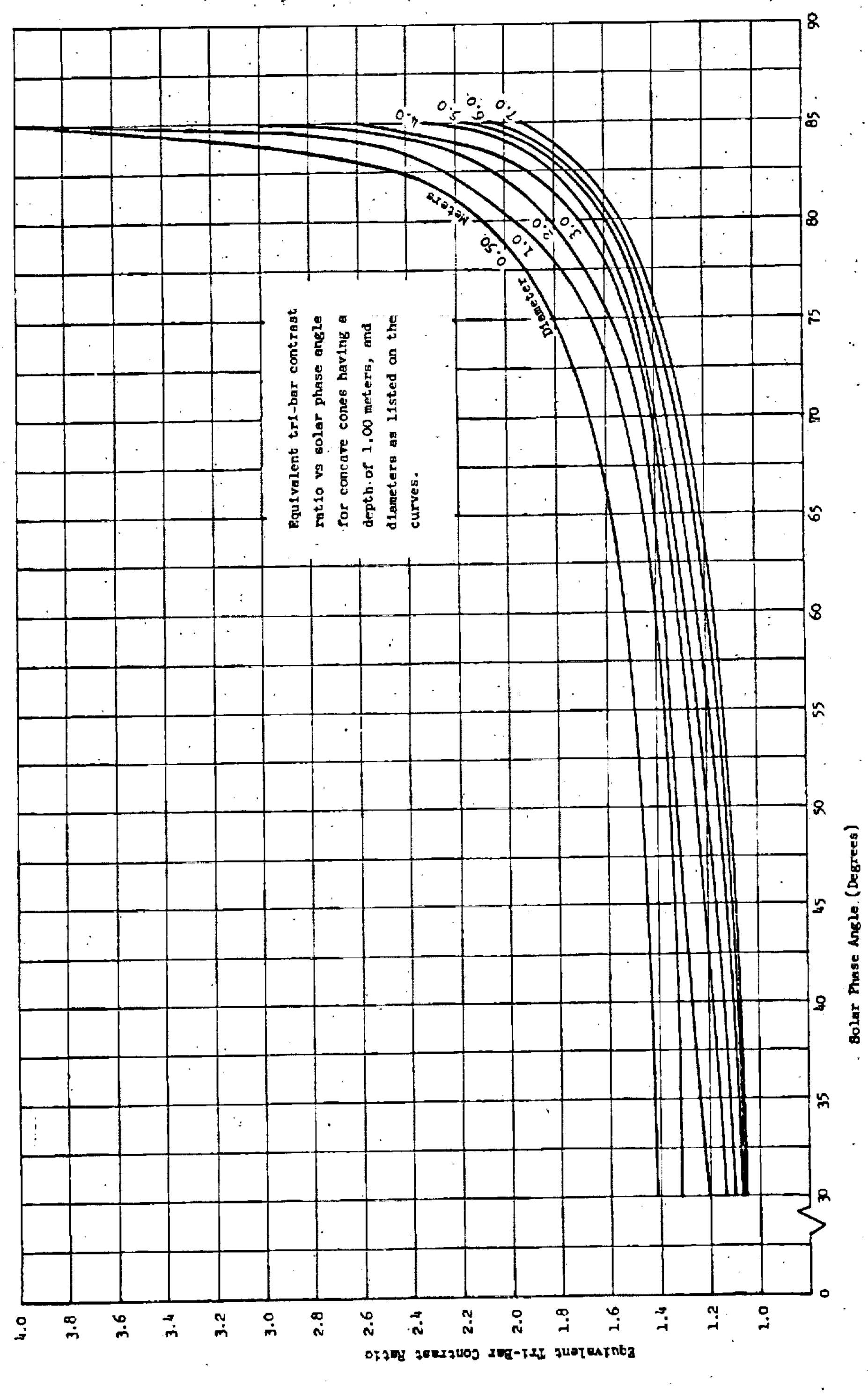



Figure 6-40. Equivalent Tri-Bar Contrast vs Solar Phase Angle

To use the figures in this section, the following procedure should be followed:

A. Determine the lens-smear-film resolution for a specific set of correlations and at a specific contrast from paragraph 6.3. For example, 70 lines/millimeter at 1.6:1 contrast.

b. Using Figure 6-37 and knowing the altitude of the spacecraft at the time convert tri-bar resolution at this contrast to crater disk size (1.2 meters at 46 km).

c. Using Figure 6-38 through 6-40, input tri-bar contrast (1.6:1) and crater disk size (1.2 meters) to each of the three graphs shown on the page. Determine the range of cone depths and solar phase angles which must be present for the cone to be detectable. For example, the cone diameter of 1.2 meters will be detectable at:

1. 80 degree solar phase angle or greater if the depth is 0.25 meters.
2. 77 degree solar phase angle or greater if depth is 0.50 meters.
3. 74 degree solar phase angle or greater if depth is 1.0 meter.

## 6.5 READ-OUT PERFORMANCE

The MTF's of the various components in the read-out link are complex functions which can vary with time; for reasons of simplicity, the MTF method will not be used here.

To determine the performance of the read-out link, tri-bar resolution targets are pre-exposed on the Type SO-243 Film in the PS. These targets can be analyzed and the limiting resolution present during read-out can be determined (integrated testing has shown that about 85 lines/millimeter at 3:1 contrast can be achieved after read-out, compared with the specified minimum of 76 lines/millimeter). Whatever the value of read-out resolution happens to be, the value can then be considered as a resolution "roof"; that is, any performance greater than 85 lines/millimeter (for example) will be read out as 85 lines/millimeter; performance below 85 lines/millimeter will be read out at the particular value. Such a roof can easily be applied to the plots presented in paragraph 6.3 by adding a horizontal line on the plots at the read-out resolution level.

# SECTION 7
# EXPOSURE

This section provides a general discussion of the concepts which must be considered in the determination of the correct exposure level for the Type SO 243 Film used. Properties of the lunar surface which affect exposure are discussed; however, detailed analyses of the variations in contrast across various shaped objects as a function of solar phase angle will not be provided. It is EKC's understanding that The Boeing Company has performed such analyses.

An analysis of the tone-reproduction characteristics of both lenses will also be included in this section.

## 7.1 APPARENT BRIGHTNESS OF THE LUNAR SURFACE

The brightness of the lunar surface is a function of a number of variables; these are defined below:

Solar illuminance: Solar energy input = 12,500 meter-candles

Lunar albedo: Surface reflectivity; generally varies between 0.06 and 0.18

Lunar photometric function: A function which accounts for the unusual diffuse reflection characteristics of the lunar surface.

The surface brightness is then given by the formula:

$$B = R\rho\phi$$

where

$R$ = solar constant = 12,500 meter-candles

$\rho$ = albedo

$\phi$ = photometric function

These terms are discussed in the following paragraphs.

7.1.1 Lunar Albedo

Earth based measurements have been made by a number of researchers to determine the albedo of the lunar surface. Such measurements were made using relatively large scanning apertures (about 500-1,000 feet on the lunar surface); it is generally assumed that the over-all average albedo of small detail on the lunar surface will, on the average, be nearly identical to the data now available from large areas. The data available at this time show that the surface albedo generally varies between 0.06 and 0.18, with about 90 percent of the observed values being between 0.06 and 0.14. Measured albedos for various regions of the surface are given in Table 7-1.

7.1.2 Lunar Photometric Function

As viewed from above the surface, the moon reflects incident light in an unusual manner, unlike either a diffuse or a specular reflector. A normal diffuse, spherical surface reflects incident light according to the cosine law, where the apparent brightness at any point on the sphere is a function of the cosine of the angle between a line normal to the surface at that point and a line connecting the point and the light source. Such a surface is called a Lambertian surface. The lunar surface, however, reflects light in quite a different fashion. The surface reflection characteristics were measured by V. A. Fedoretz who used measurements to derive the photometric function of the surface, as a function of solar phase angle ($g$) and surface angle ($\alpha$). These angles are defined in Figure 7-1. Fedoretz's photometric function is plotted in Figure 7-2, showing the variation in $\phi$ with solar phase angle, for constant values of surface angle. In Figure 7-3, simulations of the surface are used to illustrate the difference between the cosine and Fedoretz functions. It can be seen that the Fedoretz simulation closely resembles the visual appearance of the moon.

TABLE 7-1

TYPICAL LUNAR SURFACE ALBEDO VALUES

| | | Location | | Albedo |
|---|---|---|---|---|
| Maria | | | | |
| | Tranquillitatis | 9°N | 29°E | 0.066 |
| | Serenitatis | 26°N | 28°E | 0.070 |
| | Necteris | 15°S | 33°E | 0.080 |
| | Nectaris | 7°S | 26°E | 0.089 |
| | Vaporum | 10°N | 8°E | 0.062 |
| | Sinus Medii | 7°N | 8°W | 0.054 |
| | Sinus Medii | 1°N | 2°W | 0.076 |
| | Imbrium | 26°N | 0° | 0.074 |
| | Imbrium | 31°N | 17°W | 0.064 |
| | Oceanus Procellarum | 6°N | 16°W | 0.070 |
| | Oceanus Procellarum | 9°S | 24°W | 0.071 |
| | Oceanus Procellarum | 15°N | 42°W | 0.060 |
| | Oceanus Procellarum | 4°S | 54°W | 0.056 |
| Upland Areas | | | | |
| | | 4°S | 35°E | 0.104 |
| | | 3°S | 22°E | 0.118 |
| | | 9°N | 13°E | 0.090 |
| | | 2°S | 12°E | 0.123 |
| | | 11°S | 12°E | 0.125 |
| | | 7°N | 2°E | 0.104 |
| | | 5°S | 0° | 0.108 |
| | Appenine Mts. | 17°N | 2°W | 0.082 |
| | | 3°S | 8°W | 0.112 |
| Individual Features | | | | |
| | Floor of Julius Ceasar | | | 0.074 |
| | Floor of Flamsteed and Theophilus | | | 0.088 |
| | Floor of Ptolemaeus | | | 0.102 |
| | Floor of Copernicus | | | 0.120 |
| | Walls of Copernicus | | | 0.156 |
| | Rays from Copernicus | | | 0.122 |
| | Region near Kepler | | | 0.115 |
| | Central Mountain of Aristarchus | | | 0.183 |

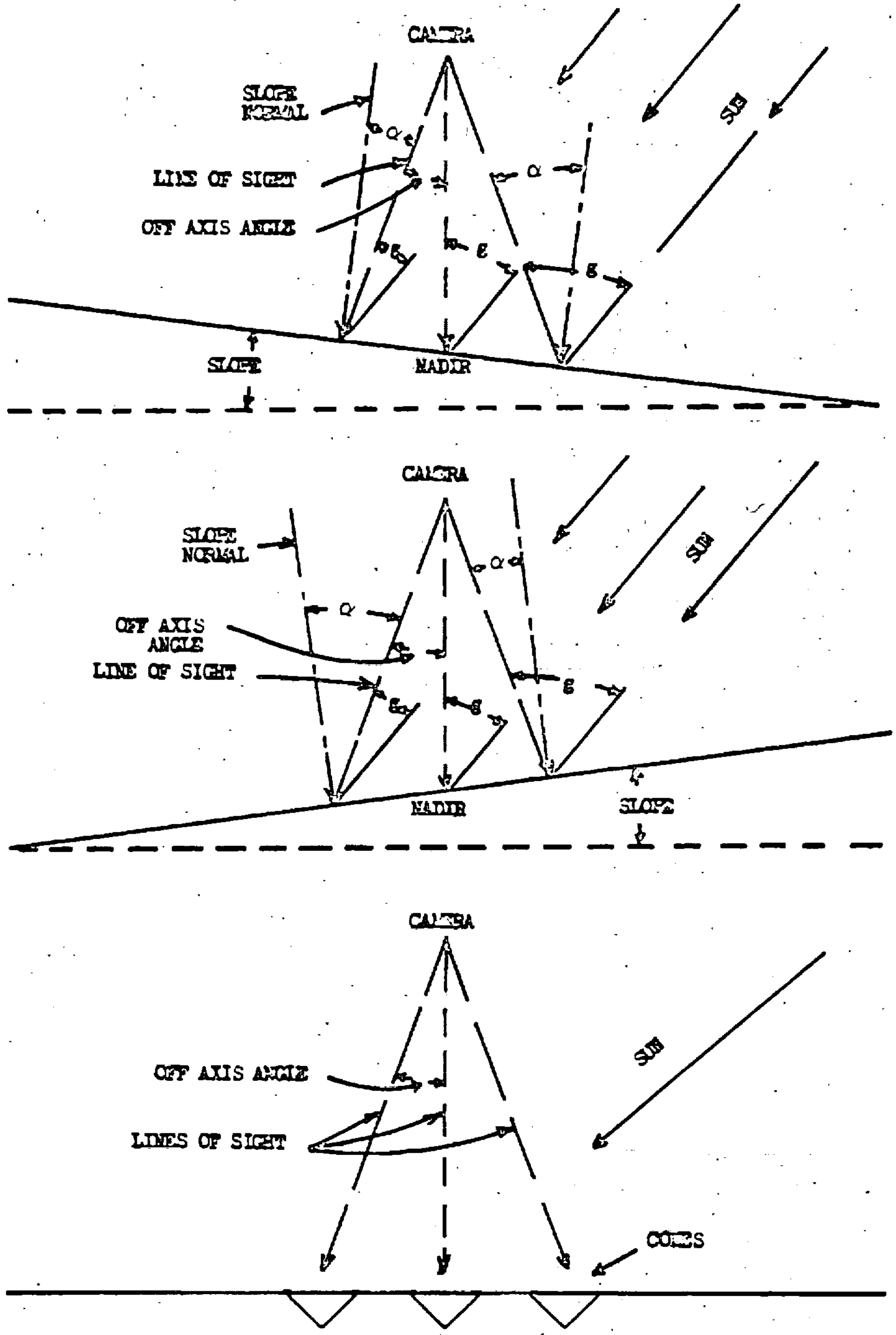
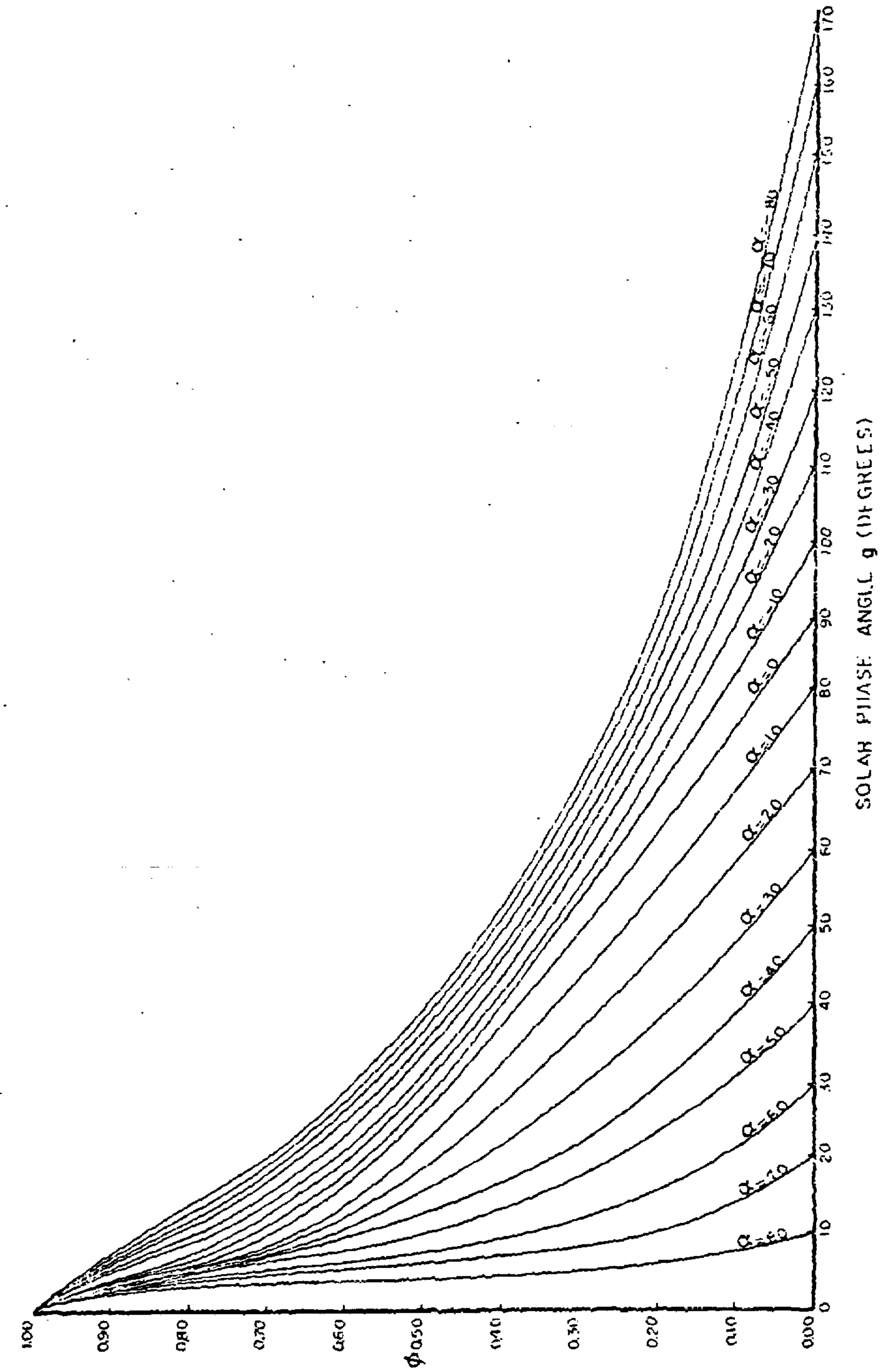



Figure 7-1. Solar Phase Angle and Surface Angle


SOLAR PHASE ANGLE g (DEGREES)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
φ
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

A number of studies were conducted at EKC, under NASA contract, to simulate the appearance of the lunar surface as a function of solar phase angle. As a result of the usual diffuse characteristics of the surface as described by the photometric function, and the lack of a scattering atmosphere, shadow detail on the lunar surface is not detectable. The effect of these characteristics is shown in the simulations in Figures 7-4 through 7-6. A simulated surface is shown in Figure 7-4, at a phase angle of 75 degrees (15 degrees above the horizon). In Figures 7-5 and 7-6 the same simulation is shown for phase angles of 80, 60, 30 and 6 degrees. As can be seen in the figures, the surface contrast decreases progressively, with nearly all detail gone at a 6-degree phase angle. For these photographs, a vertical camera angle with $\alpha = 0$ degrees was used.

Because of these restrictions, the spacecraft will be programmed to photograph only between phase angles of 50 and 80 degrees.

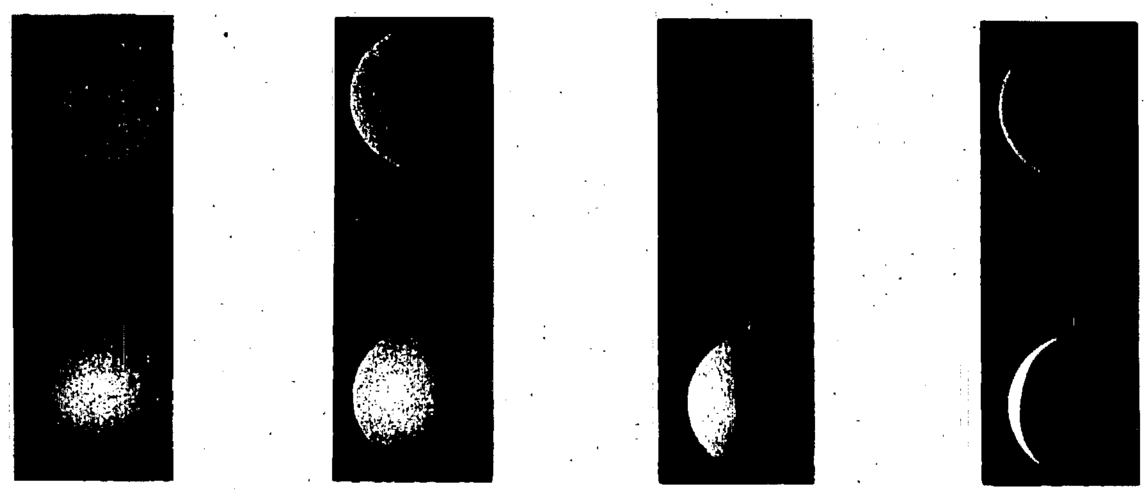
7.1.3 Lunar Surface Luminance vs Solar Phase Angle

The luminance of the lunar surface for albedos of 0.06, 0.12, and 0.18 is plotted in Figure 7-7 for a solar phase angle range of 0 to 90 degrees. The phase-angle range planned for photography is also shown on this figure.

## 7.2 IMAGE BRIGHTNESS

The relationship of illumination in a photographic image to target luminance is given below:

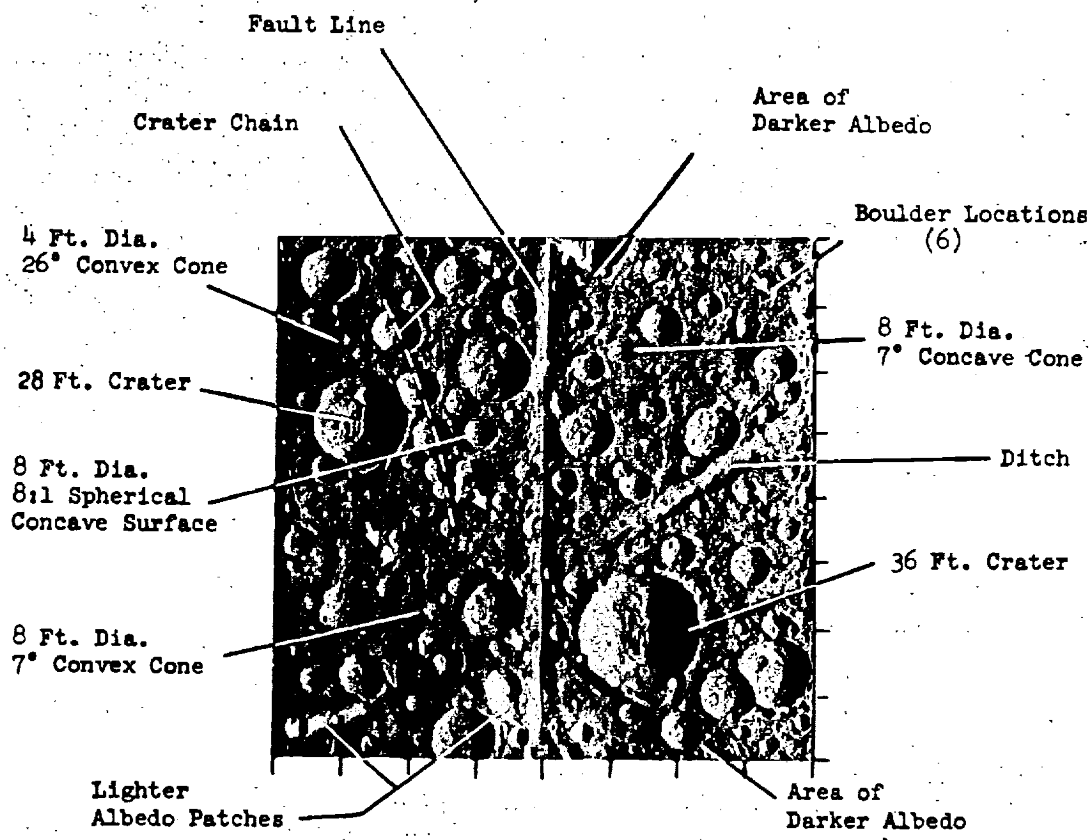
$$I_i = \frac{10.8\ KB}{4f^2}$$



Phase Angle 3° 45° 90° 155°

Comparison of Lambert reflection vs. Simulated Lunar Photometric Function reflection. The lower ball is a diffuse reflector that reflects about 6% of the incident light. The upper ball has been dusted with copper oxide to simulate the Lunar photometric function (approximately 6% albedo). It should be noted that near full moon (3 degree phase angle) the lower ball (diffuse reflector) is brighter near the center than at the edge giving it a rounded appearance, but the upper ball (Lunar photometric function) is nearly the same brightness at the edge as it is at the center making it appear more like a disk than a ball. Also the upper ball (Lunar photometric function) darkens very quickly with increasing phase angle compared with the diffuse ball. The light source subtends one-half degree.

Figure 7-3. Lambert Reflection vs Simulated Fedoretz Reflection




Scale - Scene is 160 feet on a side; each division along the bottom and right side represents 20 feet

Photograph of simulation with solar phase angle of 75 degrees (sun elevation of 15 degrees) showing the location of lunar features

Figure 7-4. Lunar Surface Model - Using Simulated Fedoretz Photometric Function

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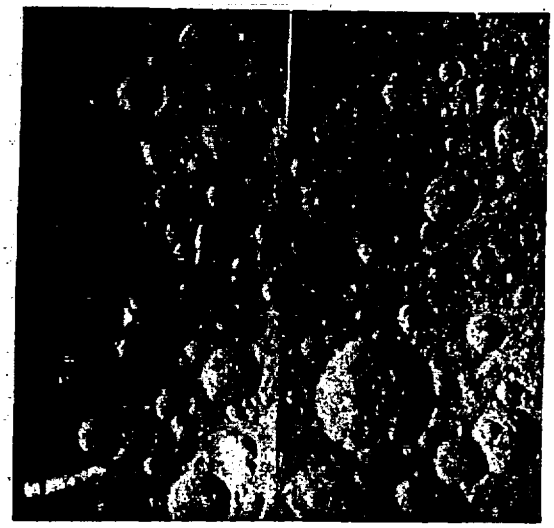
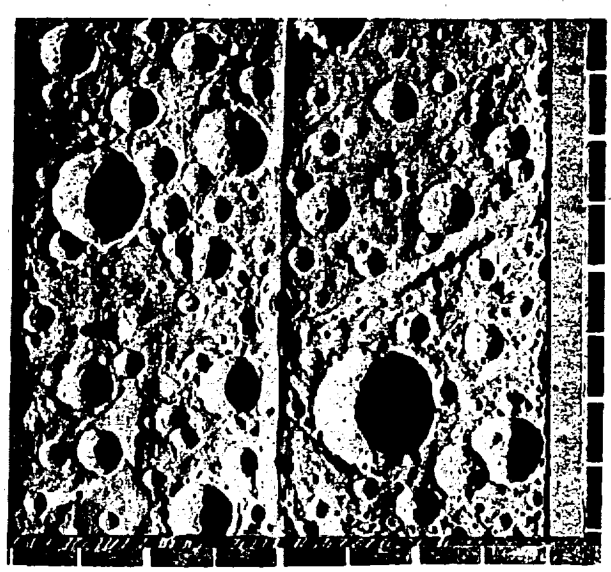


Sun Elevation = 30°



Sun Elevation = 10° with scale
along the bottom and right side

Figure 7-5. Photographs of the Simulation at Solar Phase Angles of 80 Degrees and 60 Degrees



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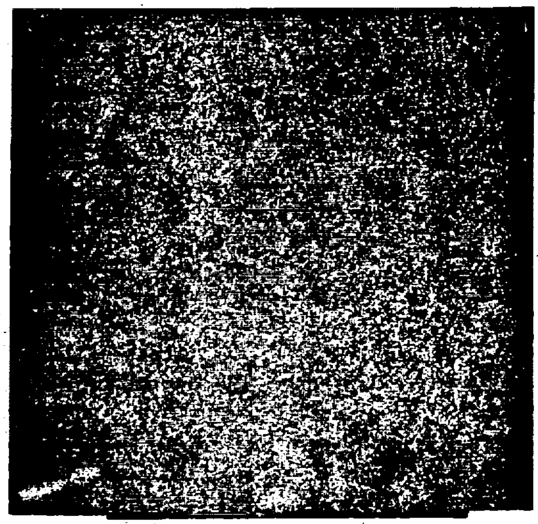

Sun Elevation = 84°

Sun Elevation = 60°

Figure 7-6. Photographs of the Simulation at Solar Phase Angles of 6 Degrees and 30 Degrees.



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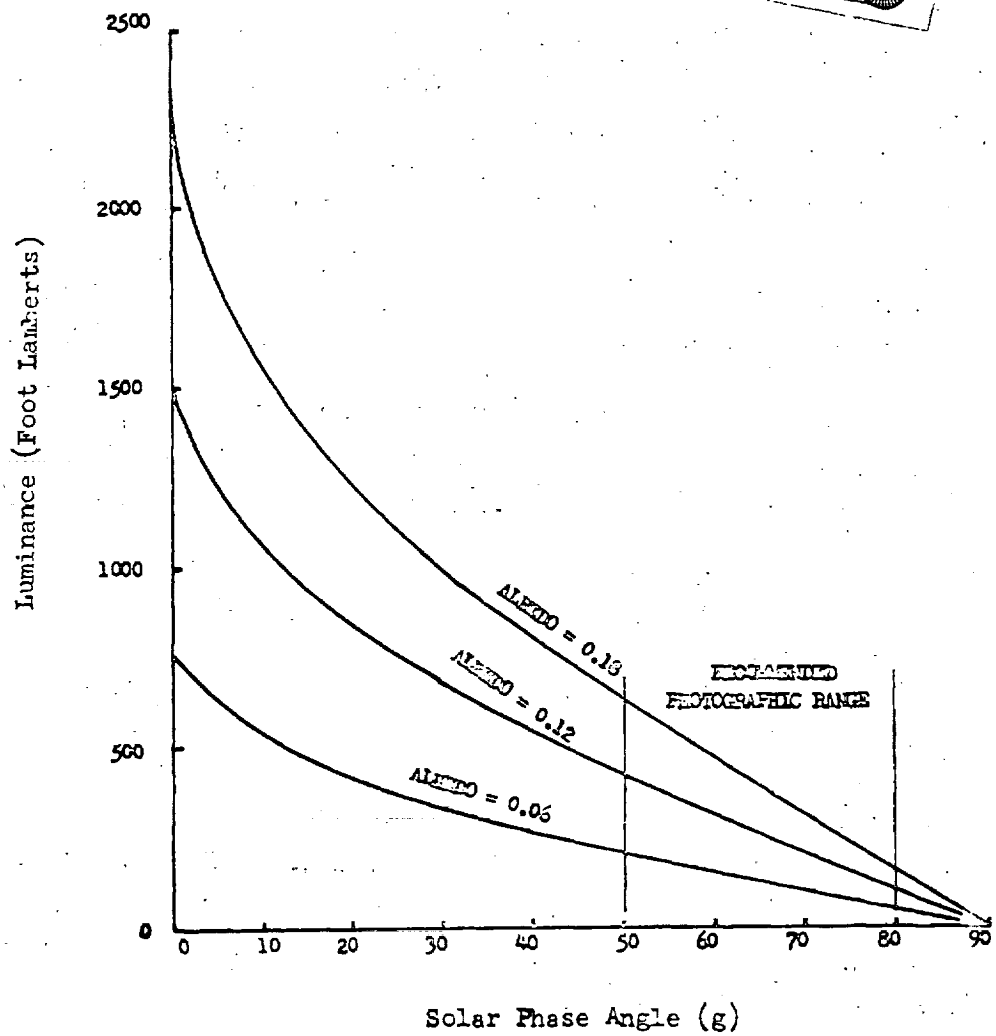



Figure 7-7. Lunar Surface Brightness vs Solar Phase Angle, For $\alpha = 0$ and a Range of Albedos

where:

$I_i$ = illumination in the image (meter-candles)

B = luminance of the target area (foot-lamberts)

f = f/no of the lens

K = transmission of the lens

For both lenses, the image illumination is as follows:

| | 24-inch lens | 80-mm lens |
|---|---|---|
| f/no. | 5.6 | 5.6 |
| K | 66 percent | 92 percent |
| $I_i$ | 0.057 (B) meter-candles | 0.079 (B) meter-candles |

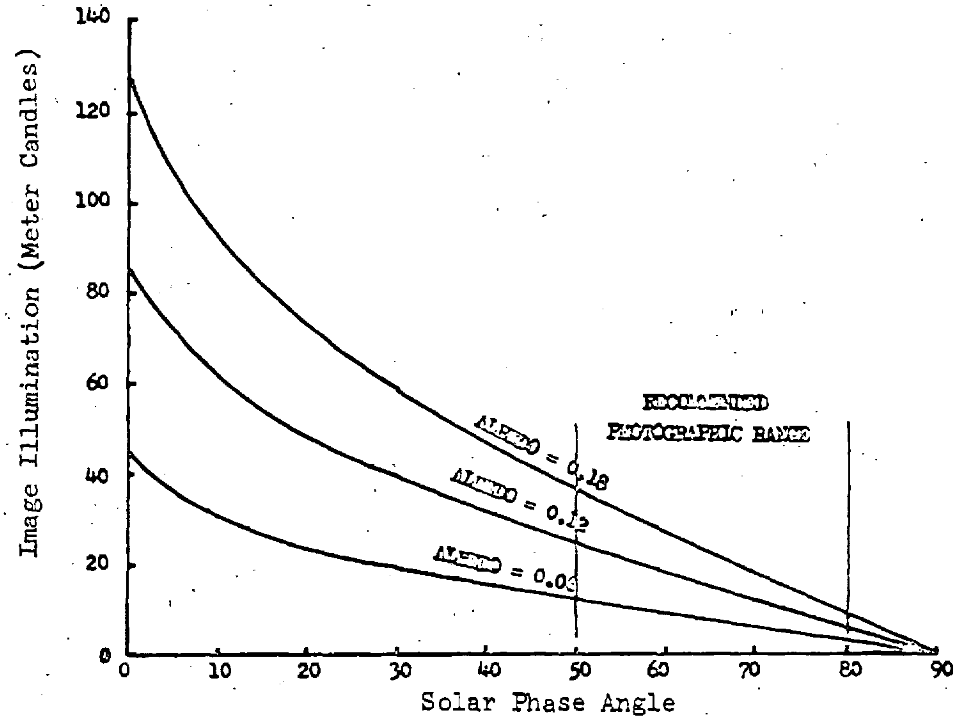
In Figure 7-8 image illumination is plotted as a function of solar phase angle for albedos of 0.06, 0.12, and 0.18. This plot is directly related to Figure 7-7, with the target luminance (B) a function of phase angle and albedo.

## 7.3 PHOTOGRAPHIC IMAGE

The characteristic curve for Type SO-243 Film with Bimat processing is given in Figure 7-9. When photographing a lunar scene, it is desirable to expose the film such that the scene luminance range falls on the linear portion of the characteristic curve. To accomplish this, for the wide range of target luminances that could be encountered, three shutter speeds are provided for each lens. In addition, the $D_{min}$ in a photograph must be 0.30 or above, to be read out accurately by the video data link.

In Figure 7-10, the recommended shutter speed is plotted as a function of phase angle, for albedo values of 0.06 to 0.18 in 0.02 increments. Note that in all cases, the surface angle $\alpha$ is assumed to be zero.

24-Inch Lens Image Brightness vs Solar Phase Angle




80-mm Lens Image Brightness vs Solar Phase Angle

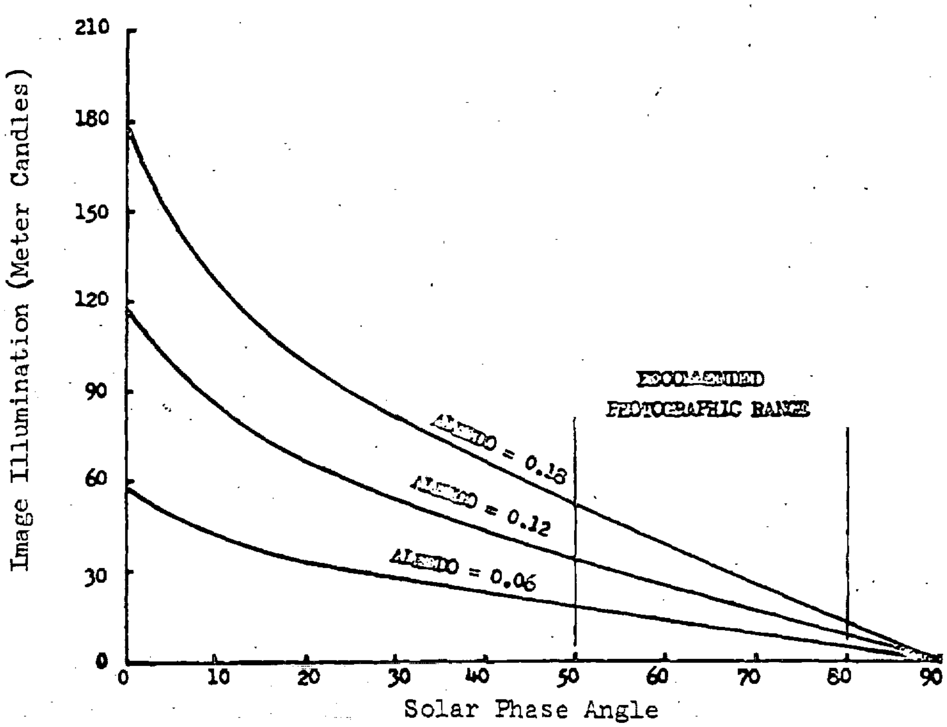



Figure 7-8. Image Brightness vs Solar Phase Angle

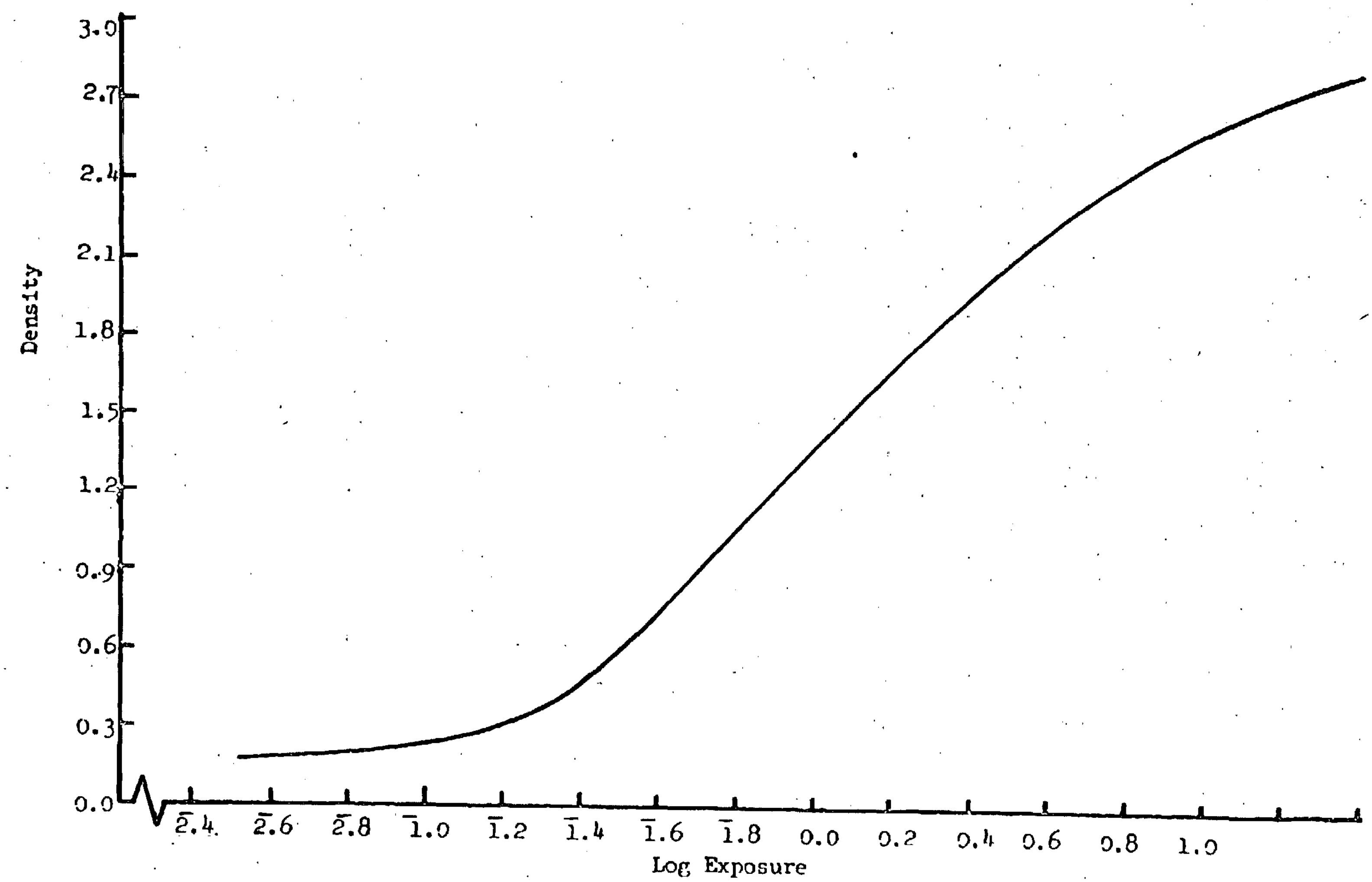



Figure 7-9. Characteristic Curve for Type SO-243 Film with Bimat Processing

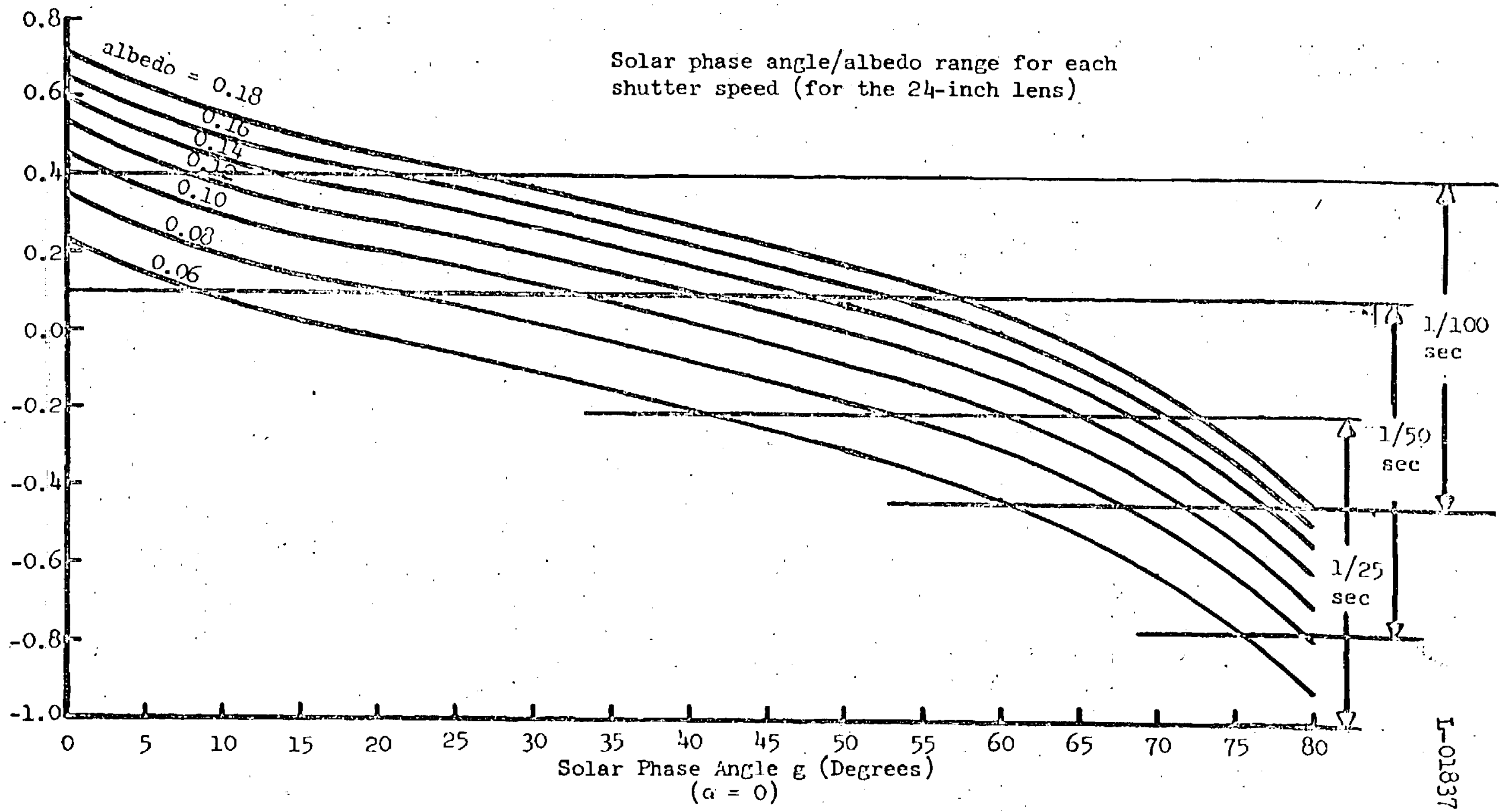



Figure 7-10. Recommended Shutter Speed vs Solar Phase Angle

## 7.4 ON-AXIS TONE REPRODUCTION

The primary purpose of the 24-inch lens is to provide high resolution photographs of the lunar surface. High resolution photography inherently implies that good photographic fidelity and accurate tone reproduction exists. Previously, in Section 6, the frequency response capability of the optical system was established. In this section, the tone reproduction capability of the system (as a counterpart to frequency response) will be determined.

The on-axis performance of both lenses is used to illustrate tone reproduction in the PS. A set of nominal tone reproduction curves are included which can be used to trace an input luminance through the system. Low frequency response functions are used.

### 7.4.1 Tone Reproduction

The over-all tone reproduction of the PS is governed by a number of components operating in series, each component having its particular tone-transfer characteristic, or transfer function. The design goal of the PS with respect to tone reproduction is to combine the transfer functions so as to optimize target detectability. Image contrast and scene latitude are opposing factors in this optimization. Target detectability can be increased by increasing contrast in the photographic image. However, as the contrast increases, the range of lunar brightness that can be displayed on the film decreases. Therefore, a compromise must be made. When all factors are taken into account, the nominal tone reproduction design is considered optimum in view of the over-all LOP performance goals.

The tone reproduction data in this section apply only to large areas, because the data are based on the low-frequency response of the system components. Except for low-frequency noise background, this method yields relatively

accurate results for 7-meter by 7-meter areas (for the 24-inch lens) or 50 by 50 meter areas (80-mm lens) if the density measurement is made with a small spot at the center of the area under examination. With larger areas, a larger spot size can be used for density measurements to reduce noise. Calculation of the tone rendition of areas smaller than these would have to take into account the high frequency response of the components and the point spread function of the over-all photographic system and are not within the scope of this section.

The quality of tone reproduction is strongly dependent on the amount of flare light present in the lens. The effects of flare light are illustrated in this section, assuming a nominal value of 2 percent of the average lunar luminance or approximately 5 foot-lamberts. This is accomplished by simultaneously tracing two exposures through the system, to the reassembled record, one with and one without the 5 foot-lamberts of flare light. The system transfer functions apply equally well in either case. The tone-producing elements are shown schematically in Figure 7-11. A summary of the tone-producing elements is given in Table 7-2.

### 7.4.2 Tone Elements

As shown in Figure 7-11, a lunar-scene input luminance enters the system through the lens, changes physical characteristics several times in passing through the various system elements and ends as a density on the reassembled photographic record.

7.4.2.1 <u>Camera Lens.</u> The first component is the lens which collects light reflected from the lunar surface. A large range of image luminances is possible because illumination depends on lunar surface albedo and the value of the photometric function over the region being photographed. The image

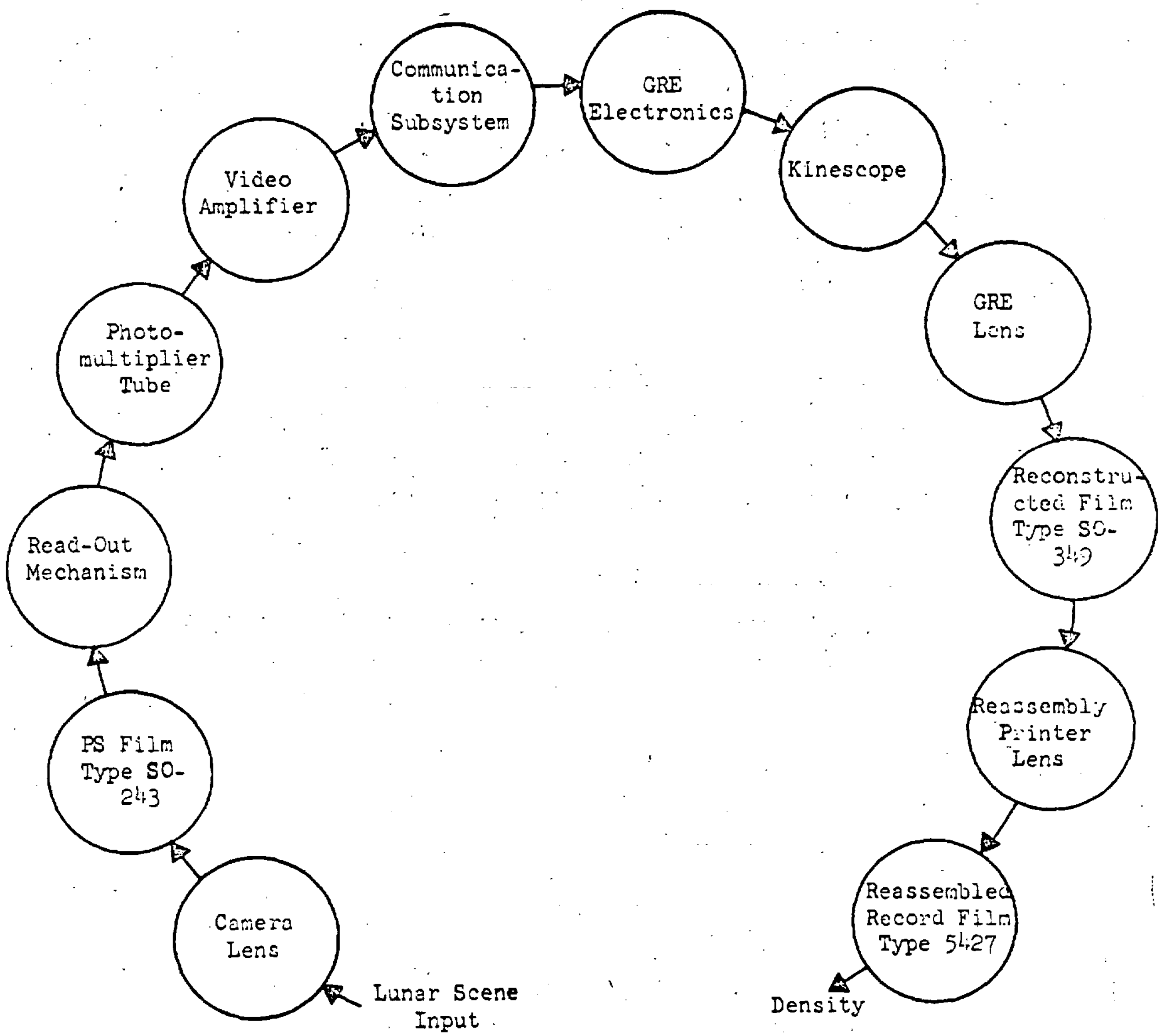



Figure 7-11. Tone Reproduction Schematic

TABLE 7-2

TONE ELEMENT DESCRIPTIONS

| Element | Description | Mission |
|---|---|---|
| Vehicle camera lens | 24-inch lens: Pacific Optical Company - EKC spec 1225-106. 80-mm lens: commercial Schneider Xenotar | Provides high resolution light imaging for photographic recording. |
| Vehicle film | Kodak Type SO-243 | Records lunar scene images for subsequent read out. |
| Read-out mechanism: A. Line scan tube | EKC Spec 1225-118 | Produces a flying-spot light source |
| B. Read-out scanner lens | EKC Drawing 400-1506 | Images the flying spot of the line-scan-tube onto the vehicle film. |
| C. Collector lens | EKC Drawing 1206-141 | Collects light transmitted by the film and directs it onto the photosensitive surface of the PM tube. |
| Photomultiplier tube | Electro Mechanical Research, Inc. Type 542 D-01-14 EKC Spec 1225-121 | Converts the flying-spot light intensity, modulated by the film density, into an electrical signal. |
| Video amplifier | EKC Spec 1225-121 | Processes the electrical signal from the PM tube and produces a video signal output. (A composite video signal is formed by the addition of sync signals. This composite signal is presented to the Communication Subsystem interface.) |
| Communication subsystem | Section 3.4.3.3 of Boeing Spec D2-100112 | Accepts the composite video signal, converts to modulated RF signal for transmission to Ground Stations, demodulates transmitted signal, and presents composite video signal to GRE. |
| GRE electronics | EKC Spec 1226-100 | Accepts composite video signal from Communication Subsystem demodulator and performs operations necessary for controlling the kinescope display. |

TABLE 7-2 (Continued)

| Element | Description | Mission |
|---|---|---|
| Kinescope | Type 5CEP16 EKC Spec 1226-101 | Displays an intensity-modulated flying spot for photographic recording. |
| GRE lens | Kodak Type M235 | Images kinescope flying spot onto the Reconstructed Record Film. |
| Reconstructed record film | Kodak Type SO-349 | Accepts and records the images formed by the GRE lens (positive image) |
| Reassembly printer lens | Goerz Artar f/11., 11" focal length | Provides imaging of reconstructed record output onto reassembled record. |
| Reassembled record film | Kodak Type 5427 | Provides directly interpretable reassembled visual picture (negative image) |

brightness parameters for the 24-inch lens are plotted in Figure 7-12, both with and without the 5-foot-lamberts flare contribution. Note: because the window attenuation is less than the lens-to-lens variation in transmission the effects of the window in the PS pressure shell are not included. See Figure 7-27 for the 80-mm lens image illumination plots.

7.4.2.2 SO 243 Film. The characteristic curve for Type SO 243 Film is given in Figure 7-13. On this Figure, read-out density was derived by compensating the standard NH blue filter densitometer readings for the correct film Q-factor. Film transmission and density are related by the equation.

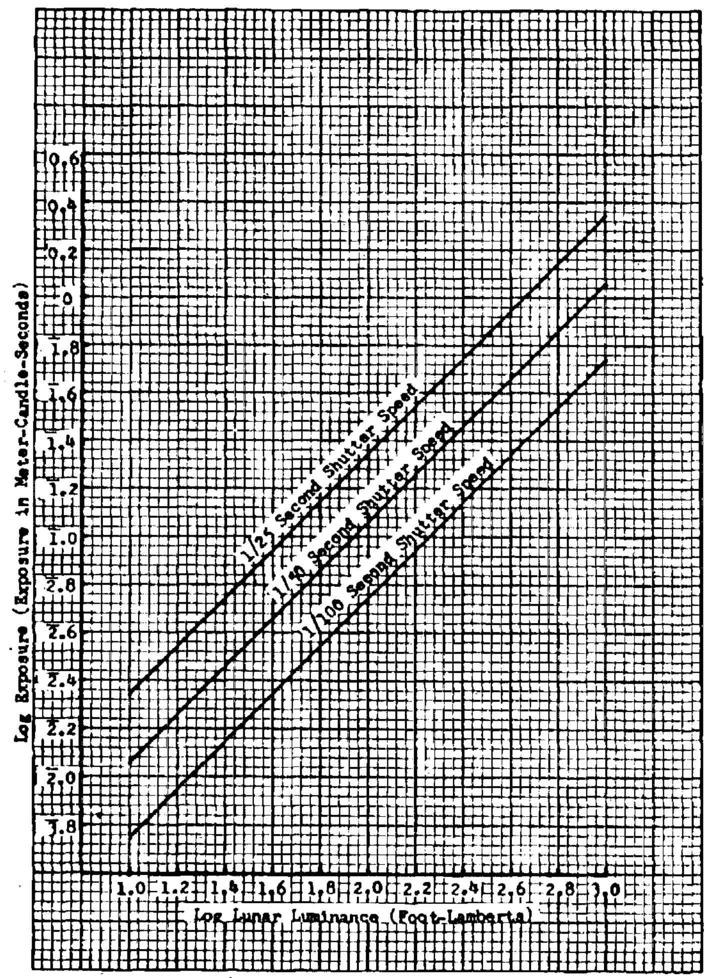
$$D = \text{Log} \frac{1}{T}$$

For convenience, this relationship is also plotted on Figure 7-13. The SO 243 film is exposed and processed to a density range of 1.0.

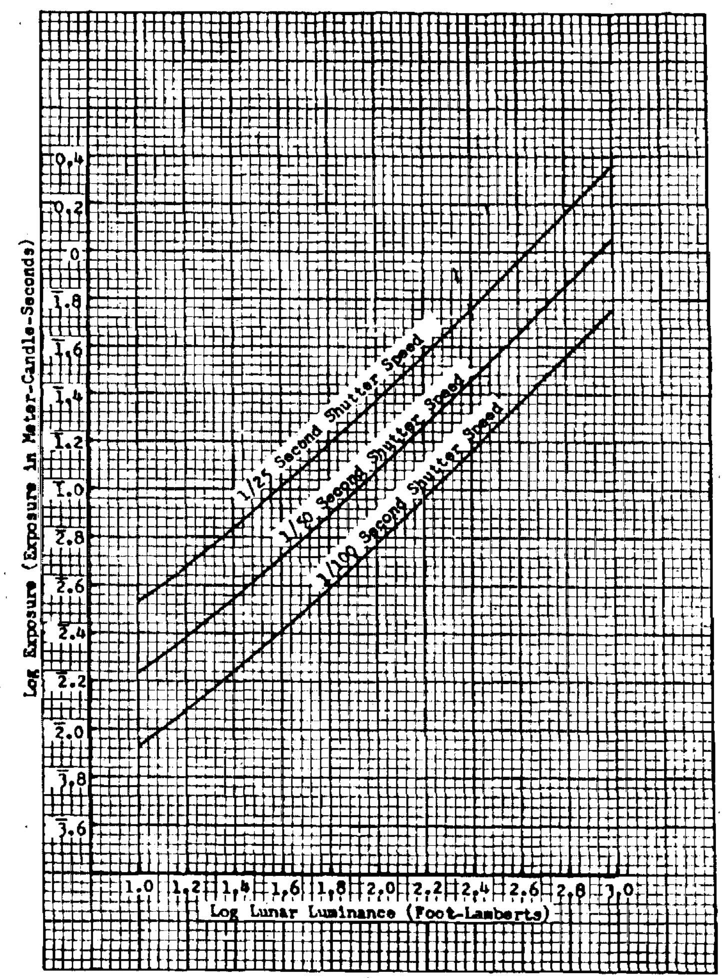
7.4.2.3 Read-out Mechanism/Photomultiplier Tube. The processed type SO 243 Film is scanned using a line-scan-tube flying spot to convert the magnitude of film transmission to an electrical signal. The spot is imaged on the film by the read-out lens, and transmitted light is relayed to a photomultiplier tube by a collector lens. The photomultiplier-tube gain is sensitive to load resistance, cathode efficiency and anode potential, among other things. The gain is adjusted to achieve the photomultiplier output voltage vs film transmission characteristic of Figure 7-14. The read-out output is considered to be at the photomultiplier tube load resistor.

7.4.2.4 Video Amplifier/Data Link/GRE Electronics. More, approximately-linear, electrical processing follows the read-out stage. A video amplifier having a gain of 100 is shown in Figure 7-15; a unity-gain data link response is shown in Figure 7-16; and Figure 7-17 gives GRE low-frequency electrical response. These are all linear estimates; obviously any real equipment will have some small nonlinearity.

L-018375-RU




24-Inch Lens Without Flare Light




24-Inch Lens With Flare Light

Figure 7-12. 24-Inch Lens - Log Exposure vs Log Lunar Luminance



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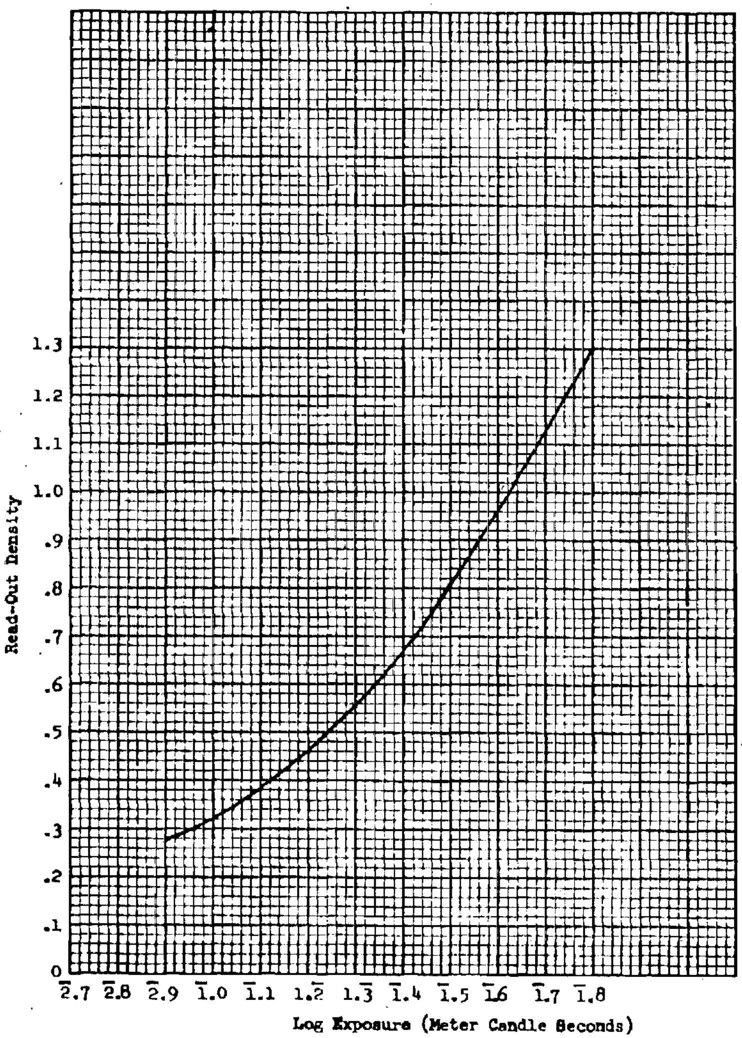
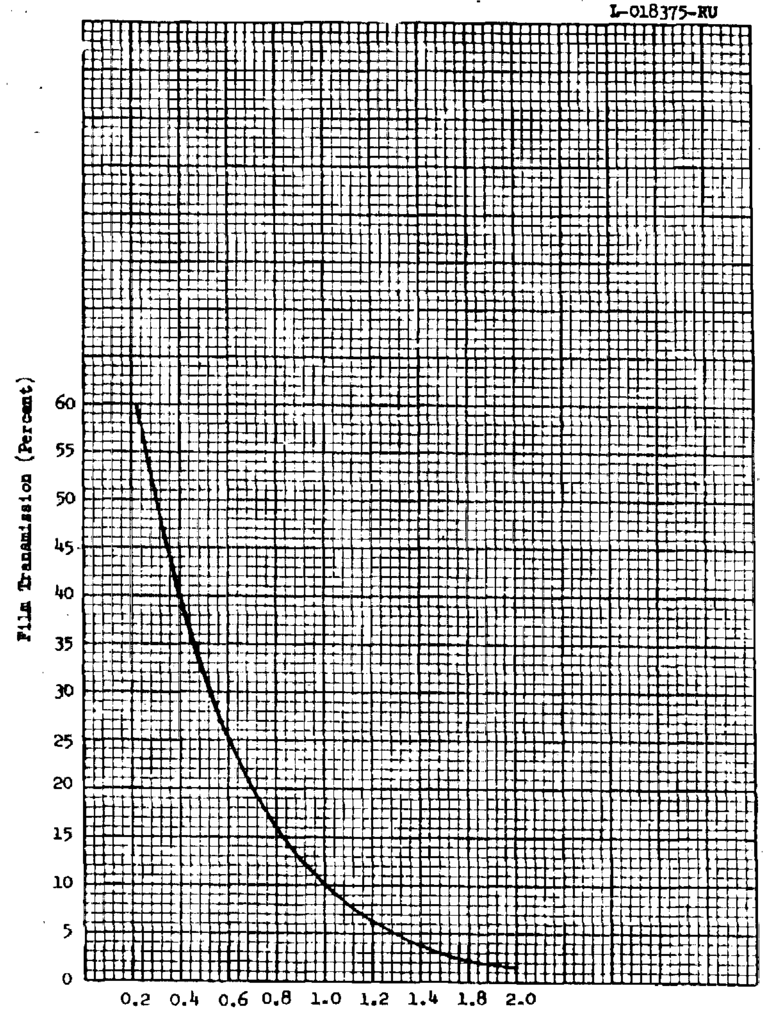



H & D Curve for Type 80-243 Film With Bimat Processing




Film Transmission vs Density

$D = \log \frac{1}{T}$

Figure 7-13. Type 80-243 Film Parameters

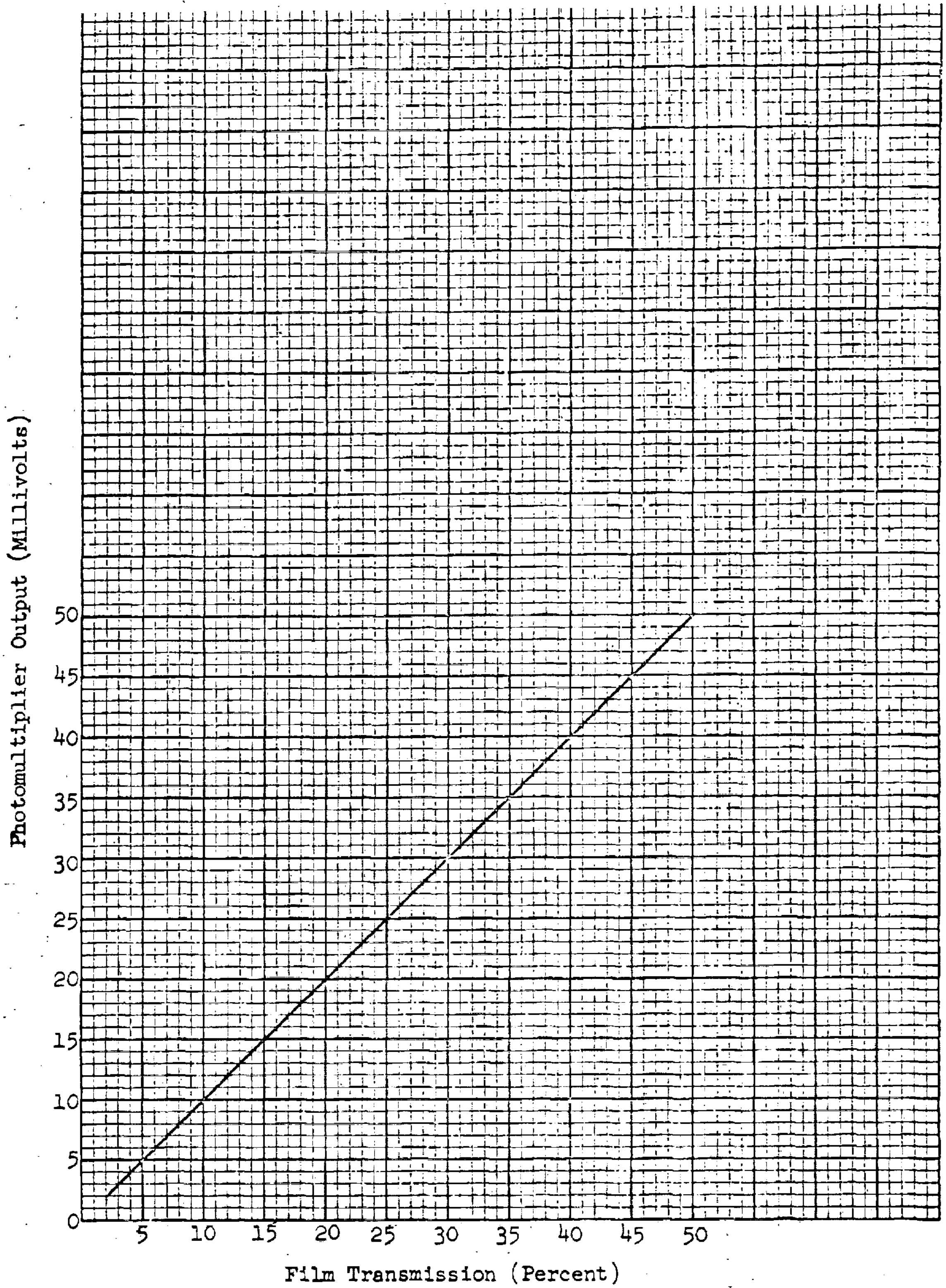



Figure 7-14. Photomultiplier Output vs PS Film Transmission

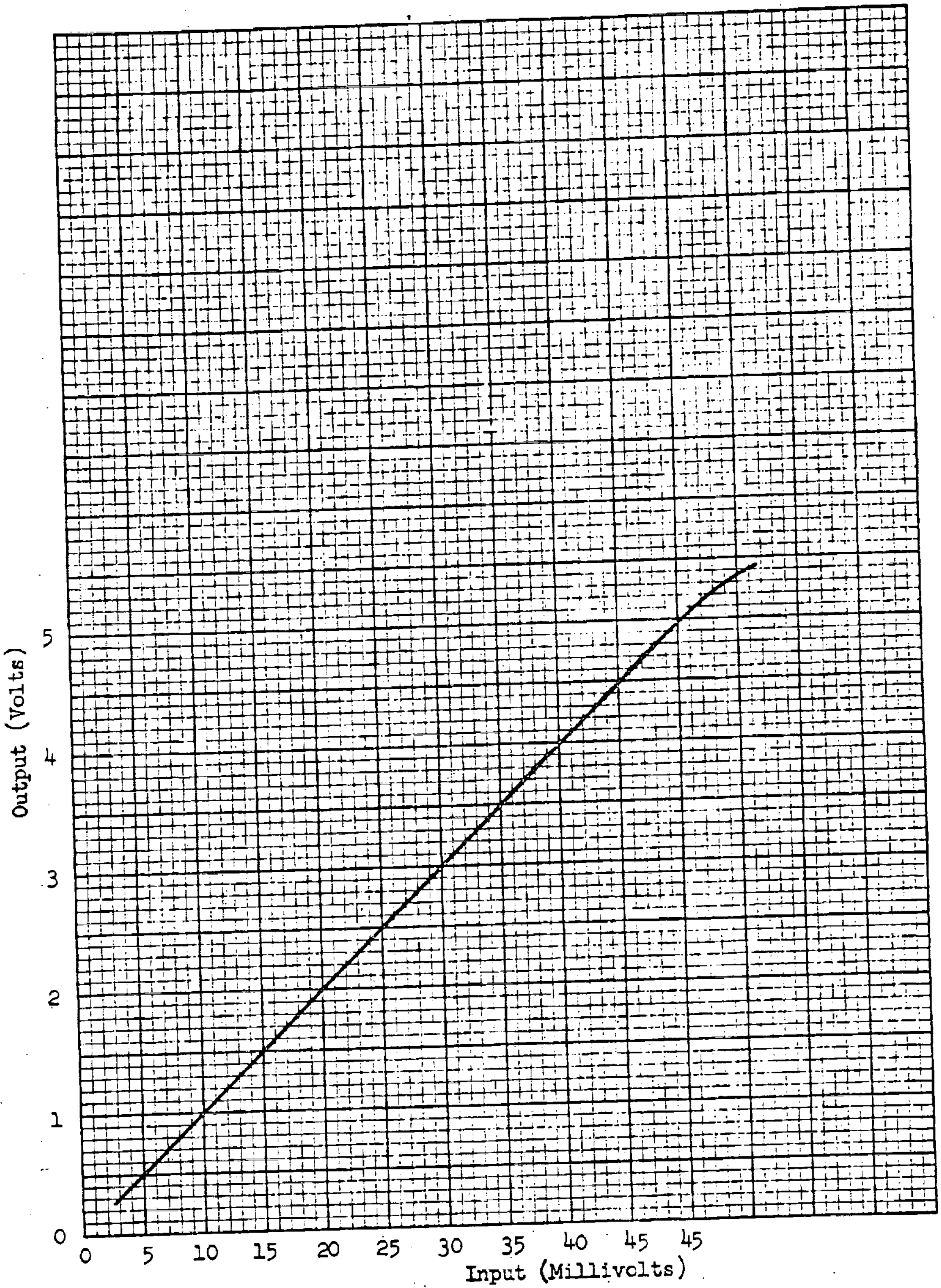



Figure 7-15. Video Amplifier Low Frequency Response

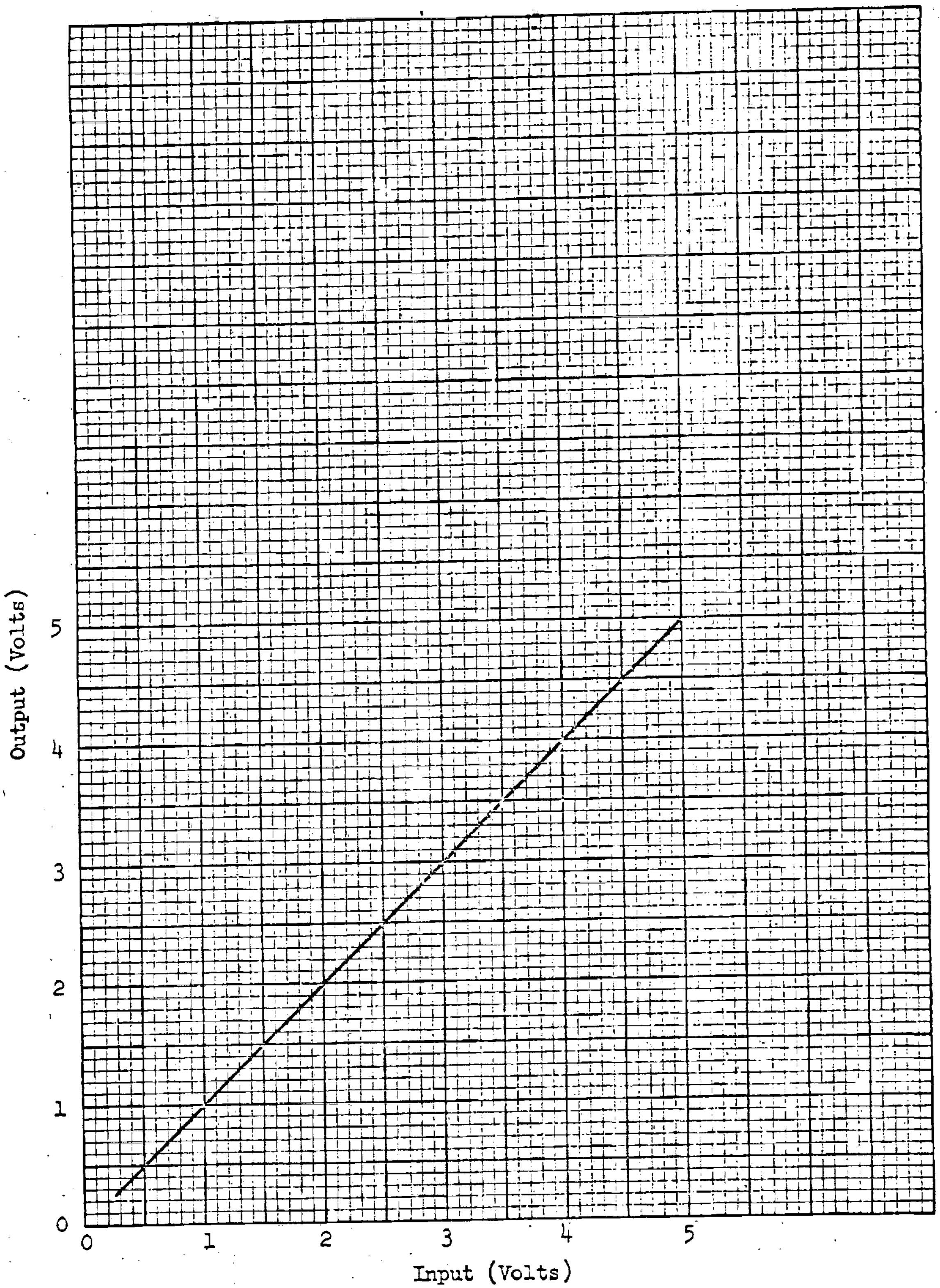



Figure 7-16. Communication Subsystem Low-Frequency Response

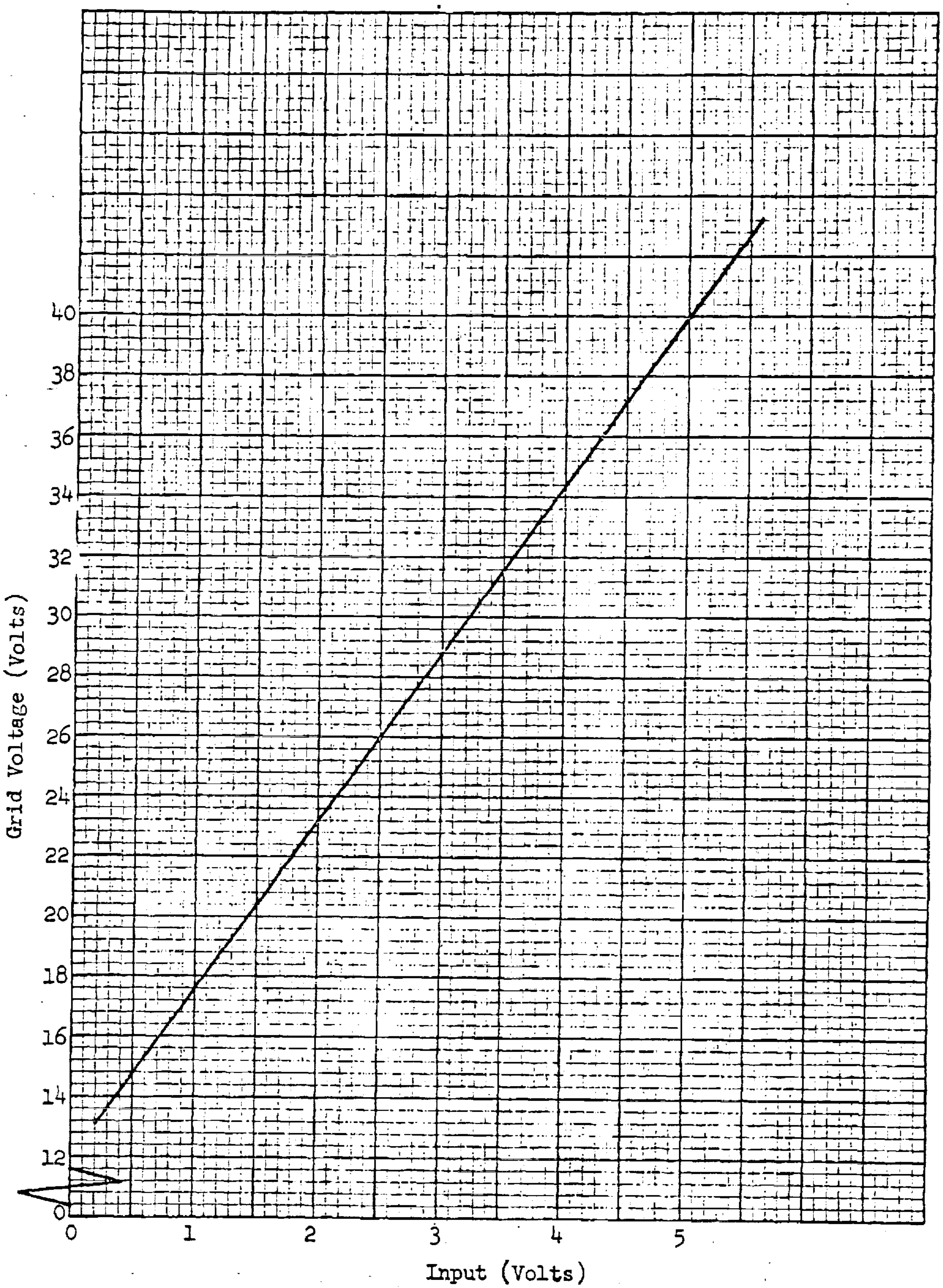



Figure 7-17. Ground Reconstructed Electronics Low Frequency Response

7.4.2.5 Kinescope/GRE Lens/Type SO 349 Film. The GRE electronics drives the kinescope grid to accomplish the nonlinear luminance variation of Figure 7-18. A relative luminance scale is used in this figure because normal photographic spot luminance measurements in lamberts are not applicable because of the spectral range of the P-16 phosphor. To compensate, the grid bias is adjusted experimentally to achieve the desired reconstructed record exposure when the lens of Figure 7-19 is used to expose the film of Figure 7-20.

7.4.2.6 Reassembly Printer Lens/Type 5427 Film. One more tone processing step is required to produce reassembled images. This step uses the reassembly printer lens of Figure 7-21 and the duplicating film of Figure 7-22. Again, nominal characteristics are given. The reconstructed and the reassembled records are exposed and processed to a density range of 1.5.

7.4.3 Tone Performance

7.4.3.1 24-Inch Lens. Combining the transfer characteristic of all of the above components gives the input lunar luminance to output density of Figure 7-23. The effect of 5 foot-lamberts of flare light is readily apparent.

As a matter of interest, Figures 7-24 through 7-26 illustrate the tone transfer characteristics present in the system, stopping at the SO 243 film, the kinescope face, and the reconstructed record (Type SO 349 Film) Note: these curves are for the 24-inch lens only.

7.4.3.2 80-mm Lens. Curves relating lunar luminance and exposure for the 80-mm lens are given in Figure 7-27. Tracing an input through the system based on the curves of Figure 7-27 results in the 80-mm

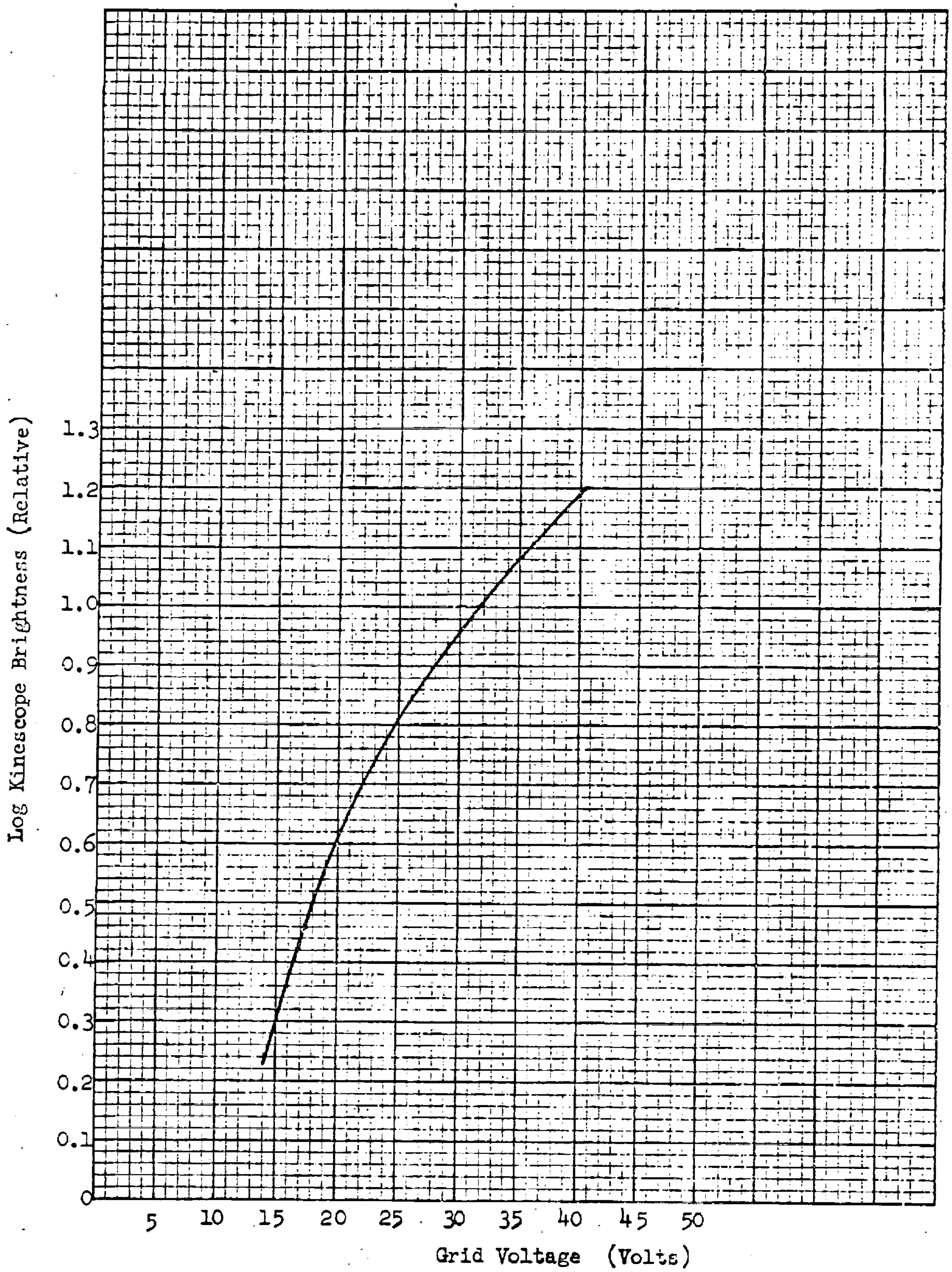



Figure 7-18. Log Kinescope Brightness vs Grid Voltage

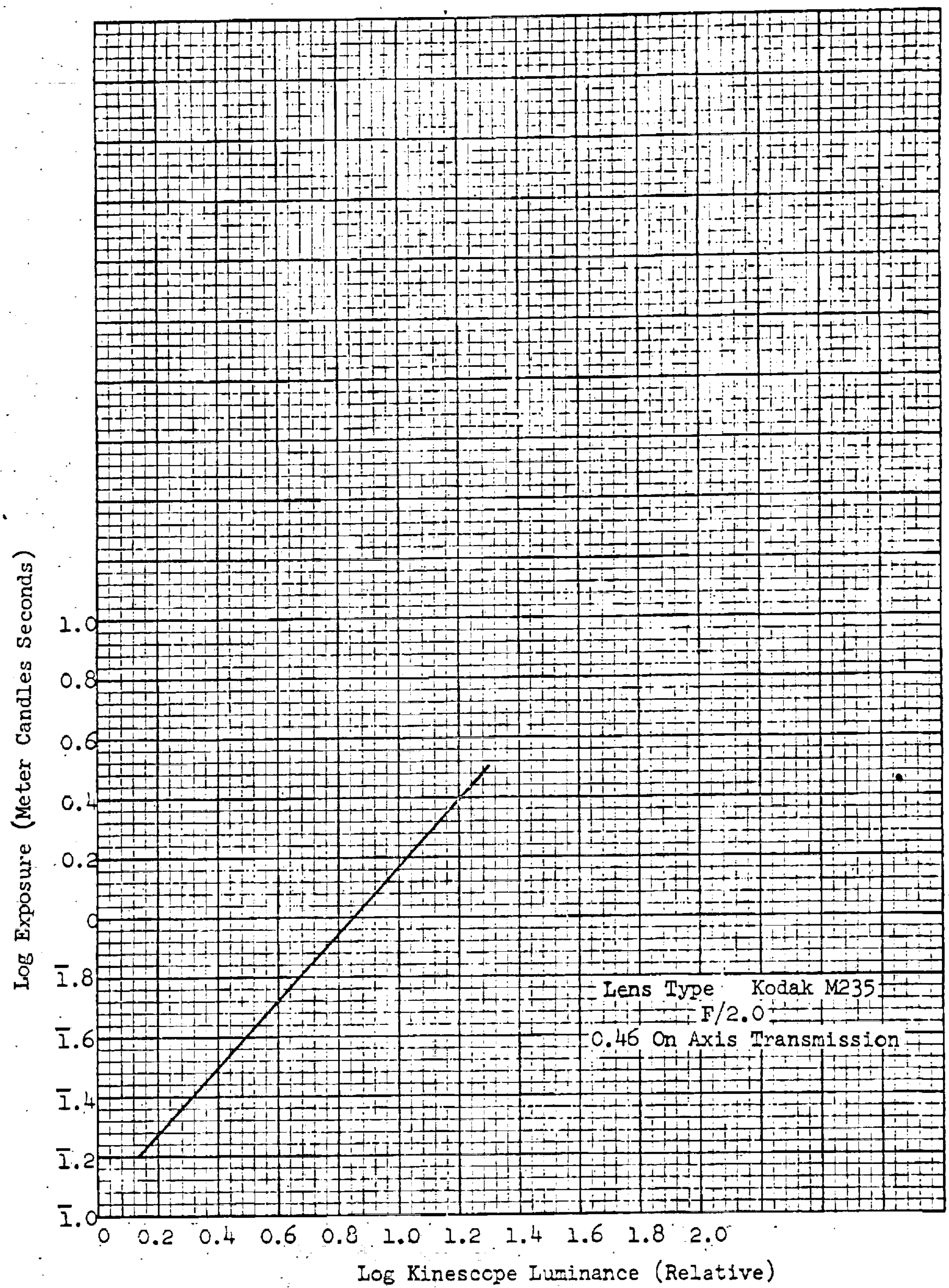



Figure 7-19. Log Exposure vs Log Kinescope Brightness

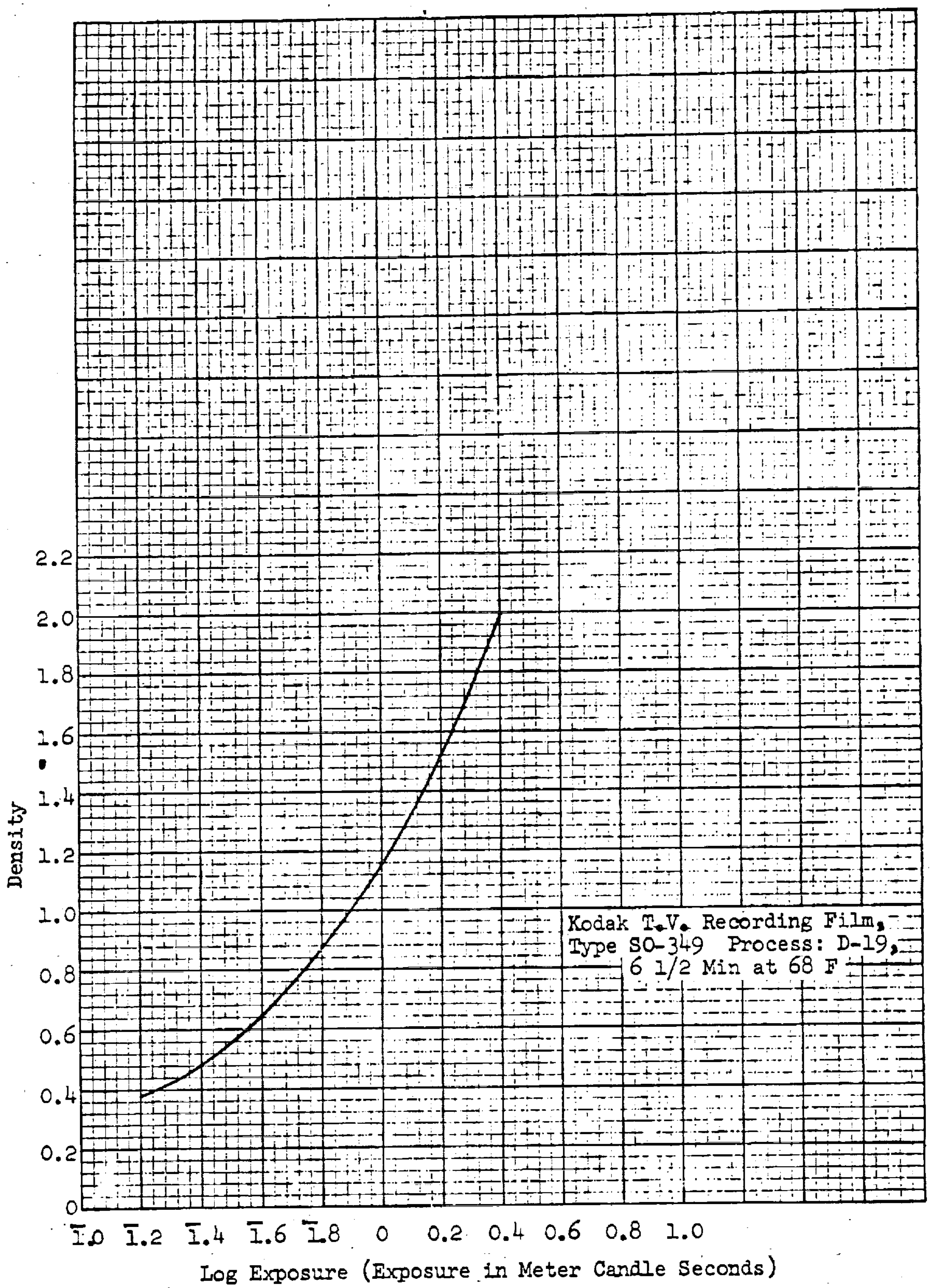



Figure 7-20. H & D Curve for Kodak Television Recording Film, Type SO-349 (35 mm)

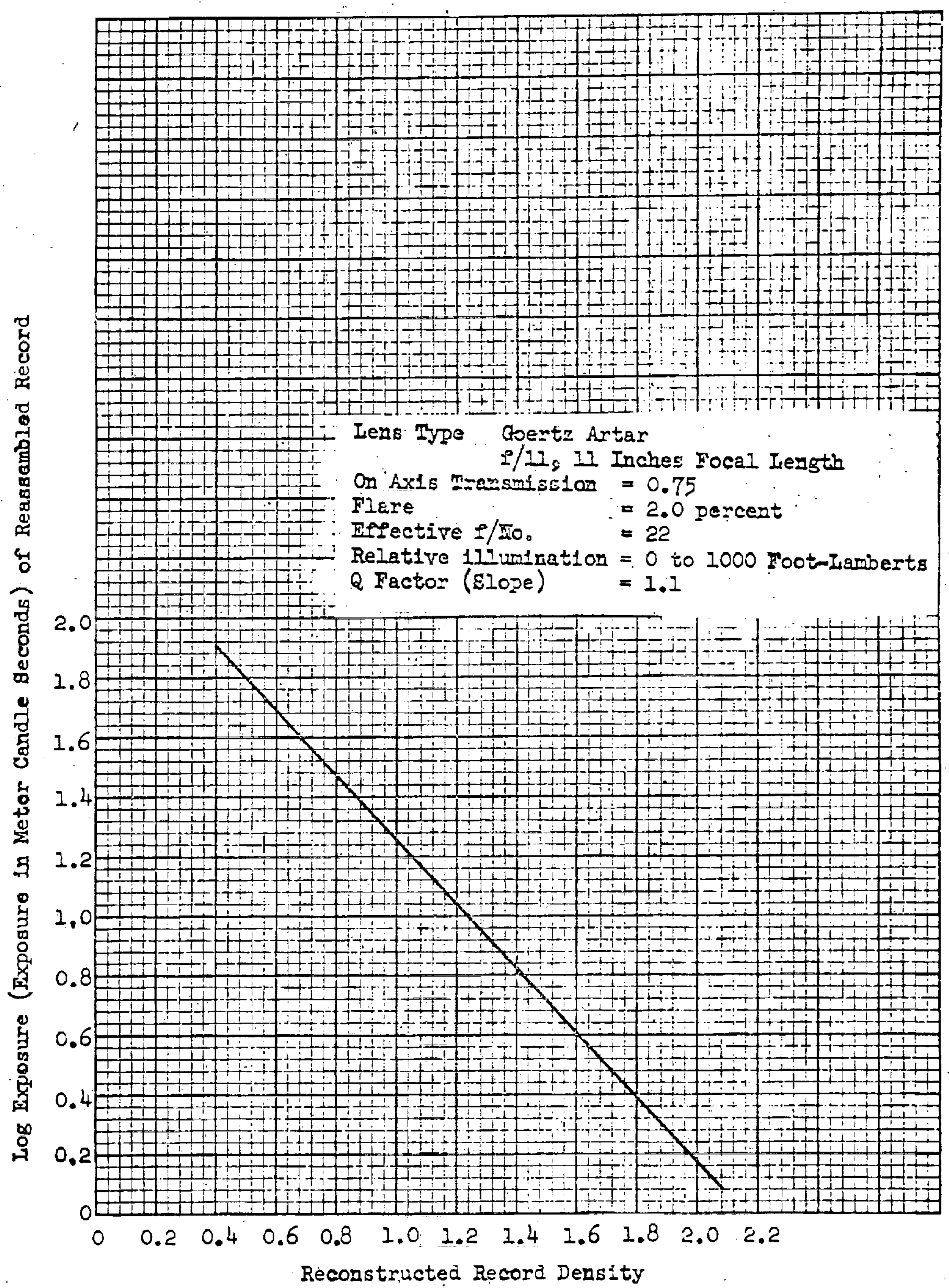



Figure 7-21. Reassembly Printer Transfer Characteristic

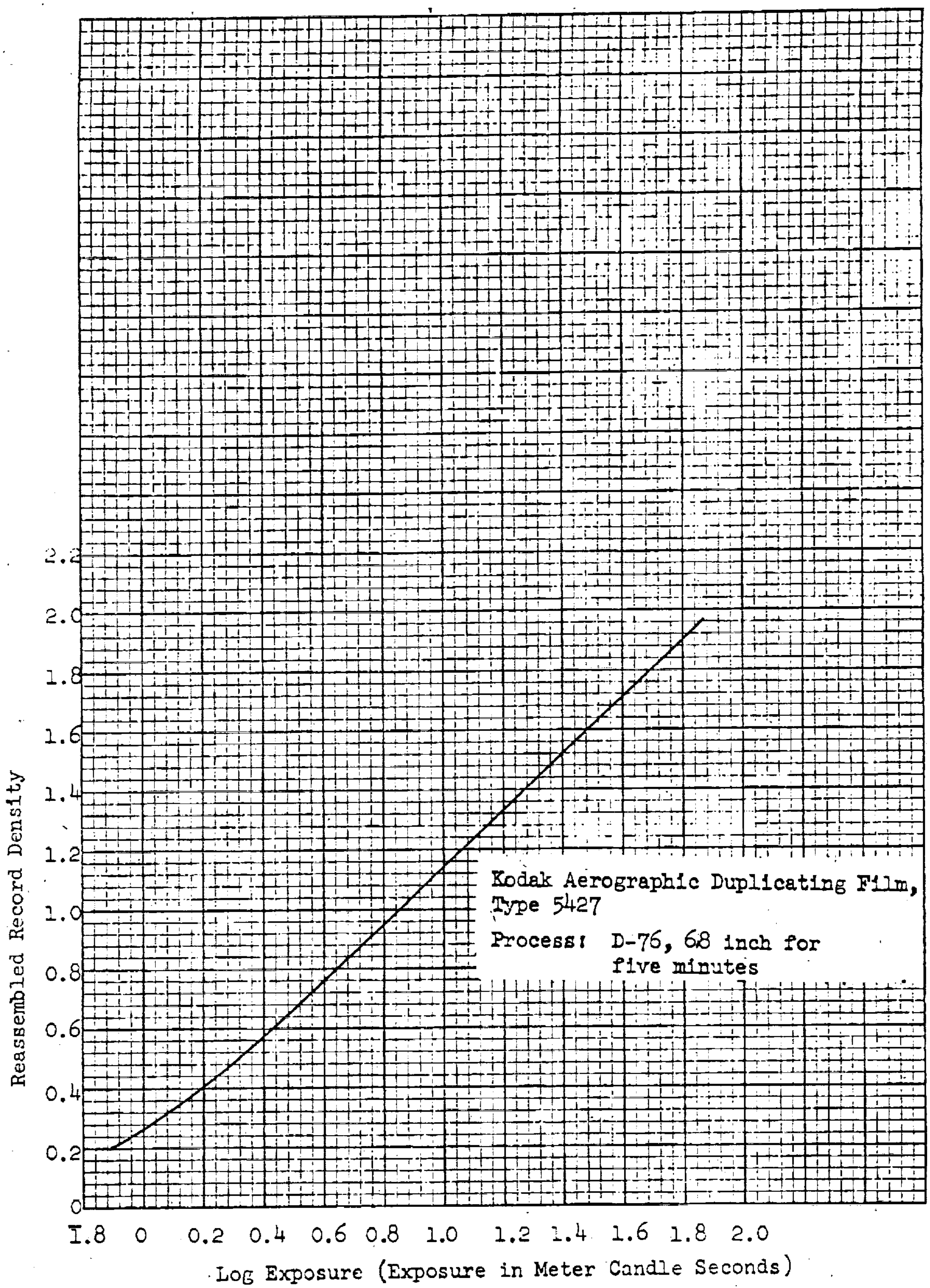
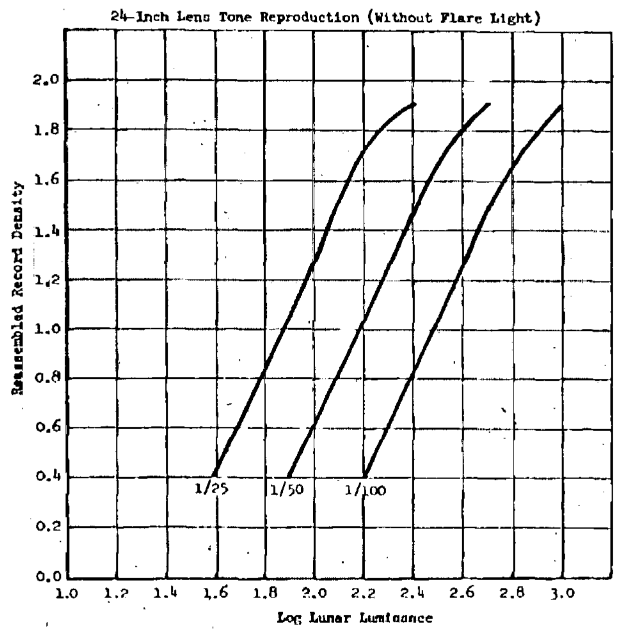



Figure 7-22. H & D Curve for Kodak Aerographic Duplicating Film, Type 5427 (Reassembled Record)



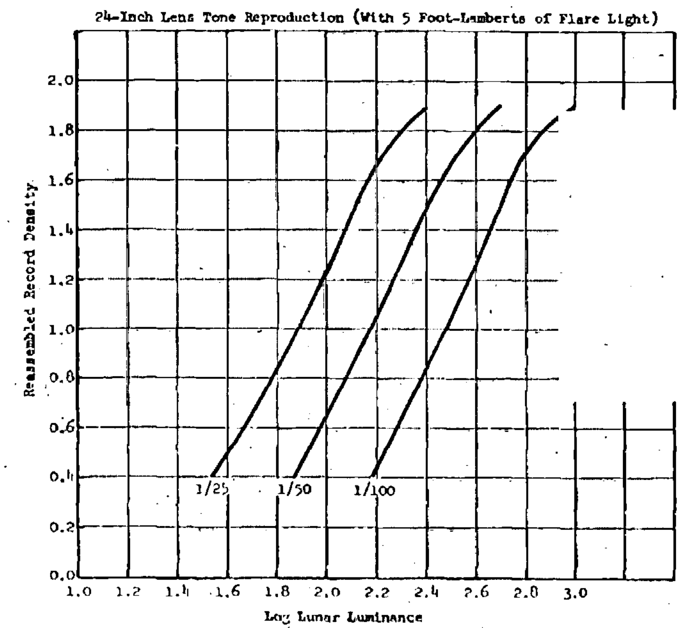
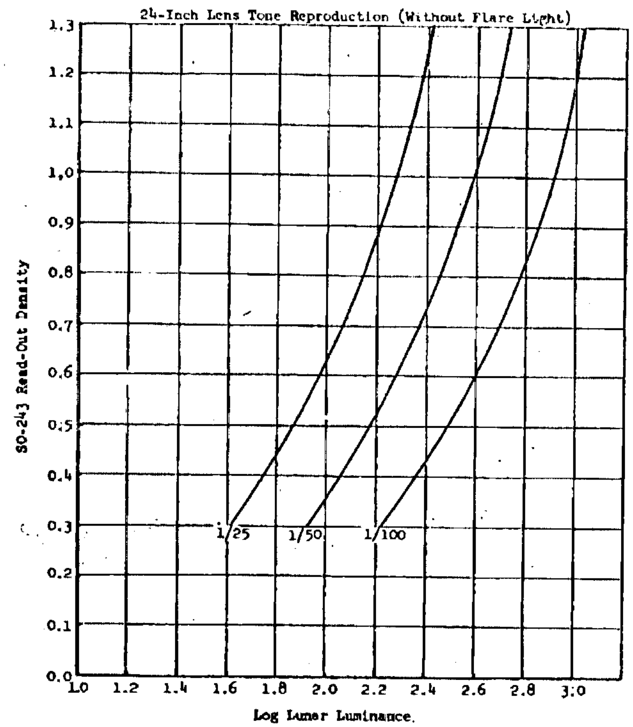




Figure 7-23. 24-Inch Lens Tone Reproduction



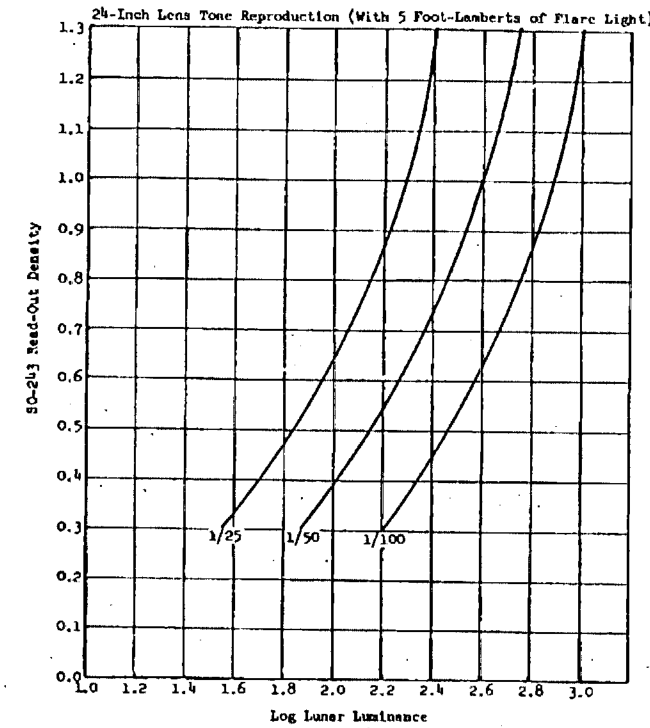
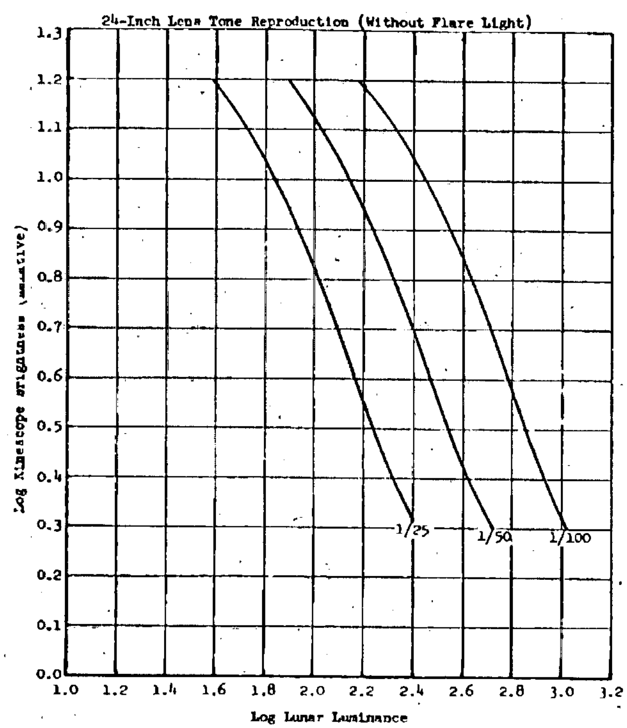




Figure 7-24. 24-Inch Lens Tone Reproduction Characteristics, On the SO-243 Film.



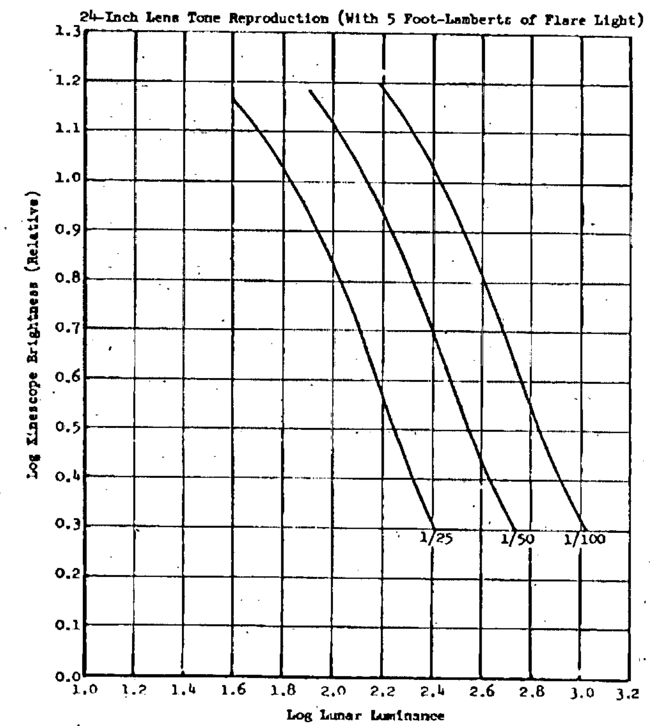
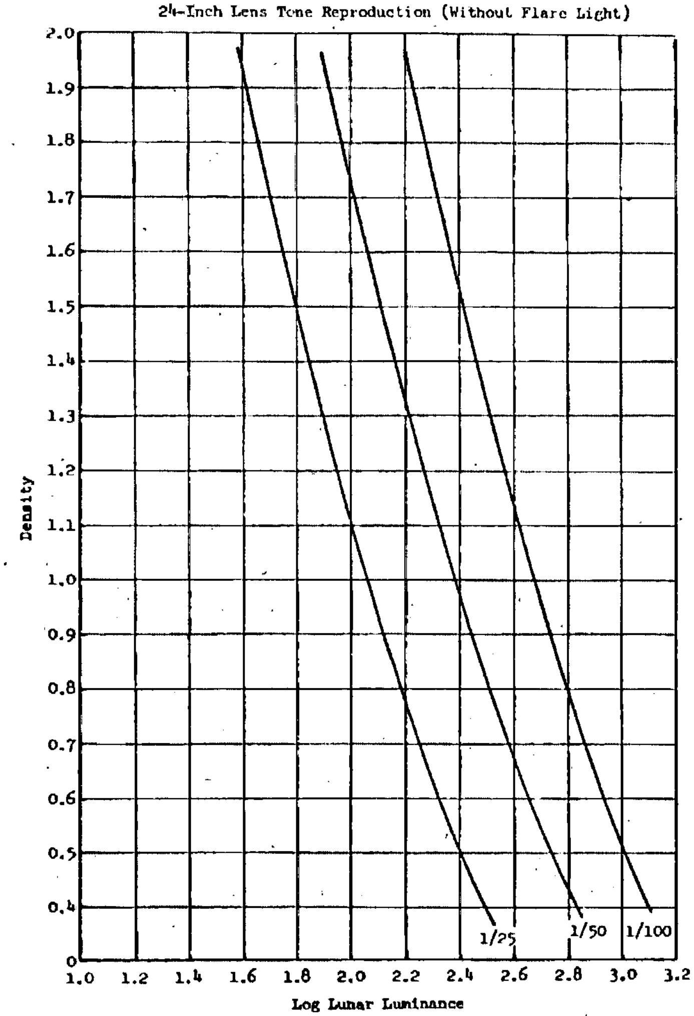




Figure 7-25. 24-Inch Lens Tone Reproduction Characteristics, On the Kinescope Face



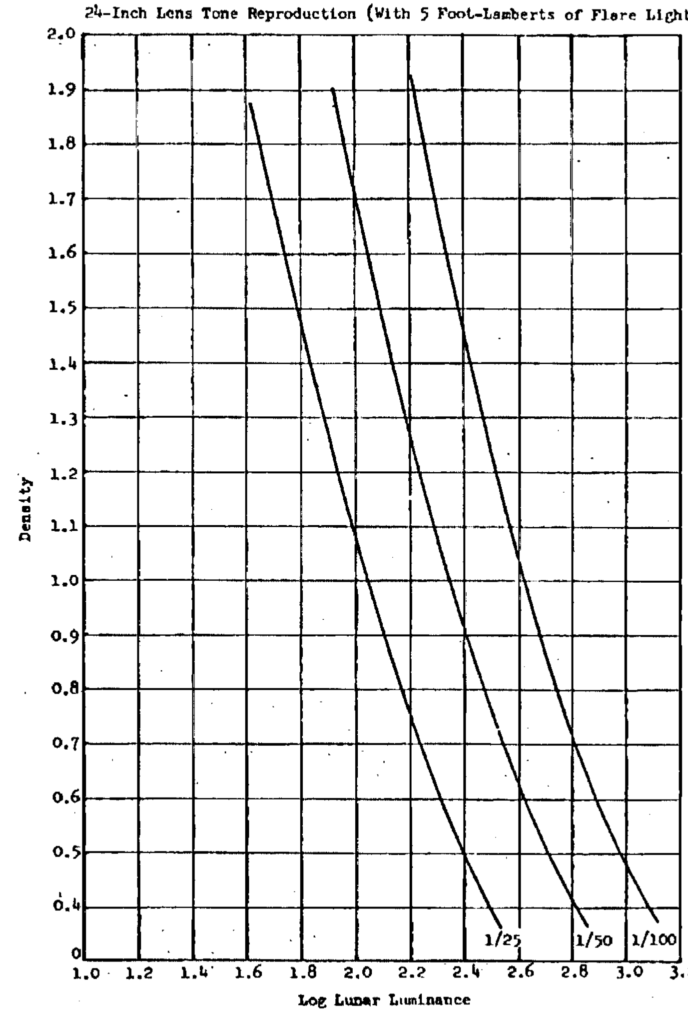




Figure 7-26. 24-Inch Lens Tone Reproduction Characteristics, On the 35-mm Reconstructed Record (Type SO-349 Film)

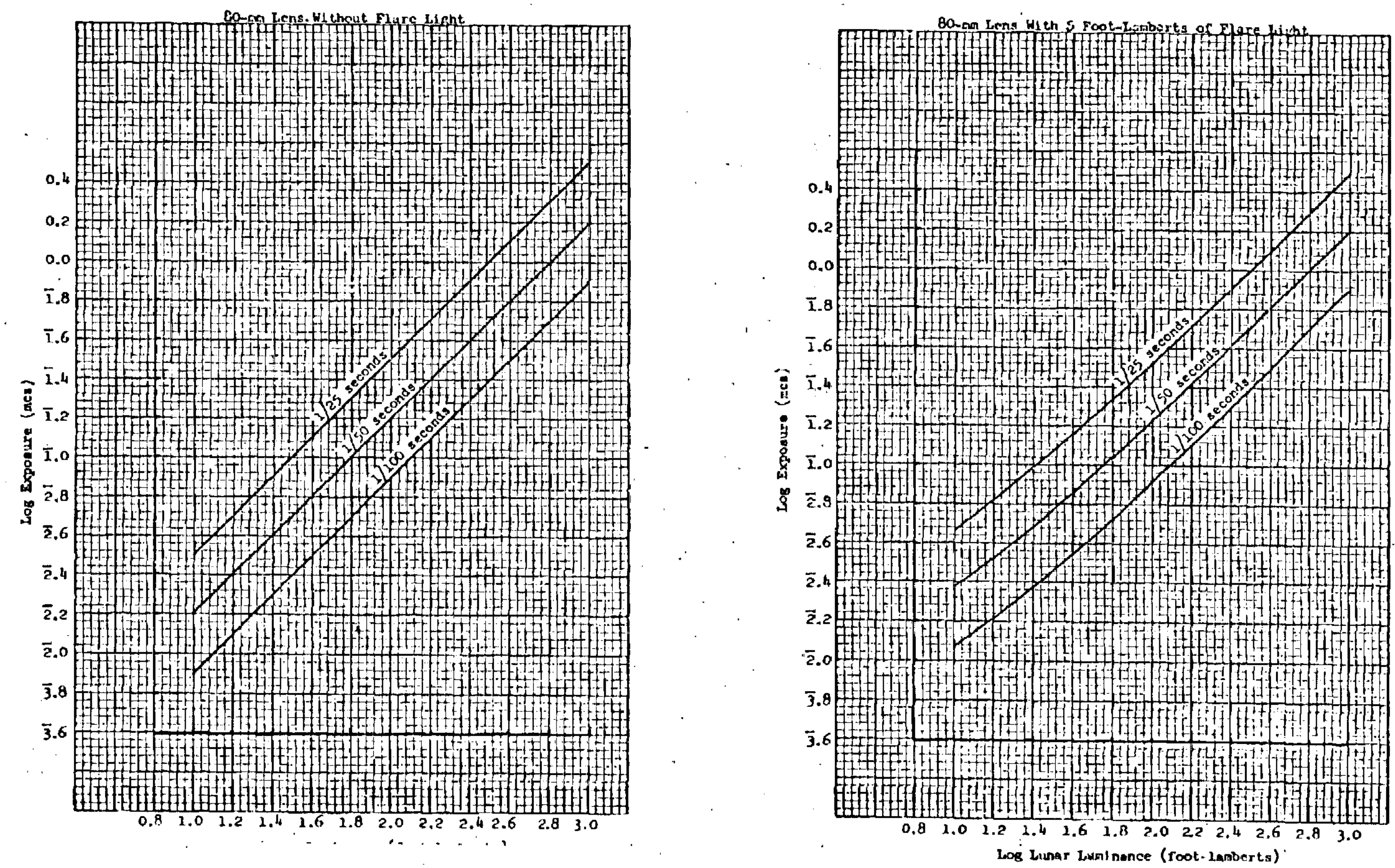



Figure 7-27. 80-mm Lens-Log Exposure vs Log Lunar Luminance

lens tone reproduction curves shown in Figure 7-28. The process followed is exactly the same; only the image brightness parameter has changed.

### 7.4.4 Summary

The predicted tone reproduction characteristic of the LOP system, as exhibited in the curves of Figures 7-23 and 7-28, is considered to be satisfactory. The flare light renders a slight increase in the reassembled record density, primarily at the lower portion of the lunar luminance range. However, in both the presence and absence of flare light, the linearity and slope of the curves are such that the reassembled record image will appear as a faithful rendition of the original scene. The contrast has been increased to accommodate the human eye and, incidentally, also matches the maximum contrast at which reflection prints can be reproduced. Accordingly, the photographic output should be highly satisfactory for visual interpretation of the lunar data.

Note: The maximum density latitude of the reassembled record corresponds to a rather restricted luminance range in the original scene. The primary reason for this restriction is the need for maintaining a high signal-to-noise ratio throughout the information handling channel. This is accomplished by restricting read-out to a density range of 0.3 to 1.3 on the Type SO-243 Film.

The curves of Figures 7-23 and 7-28 are based on a combination of measured and estimated data. Later data may show that some of the component curves that contribute to over-all tone reproduction must be changed. This does not imply that the curve shapes of Figures 7-23 and 7-28 significantly. There are many opportunities for adjusting the system: for example, by adjusting the photomultiplier anode voltage or kinescope bias and gain, or by changing the

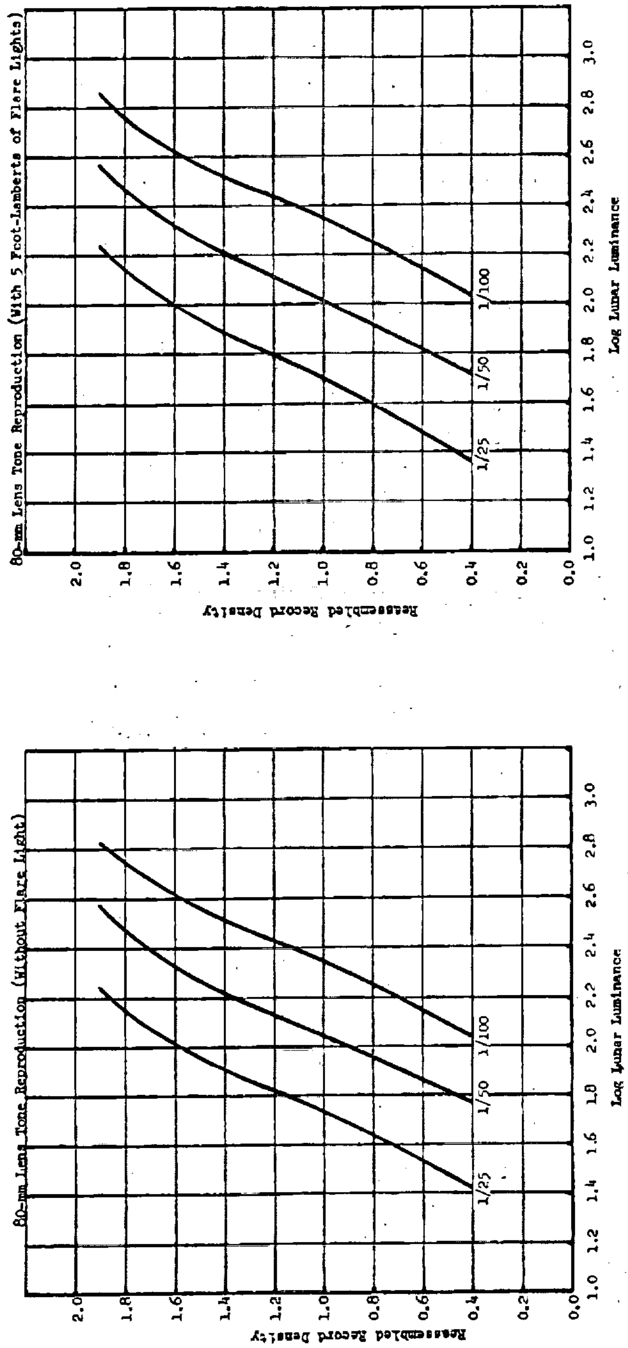



Figure 7-28. 80-mm Lens Tone Reproduction

processing parameters of the reconstructed or reassembled records. This ensures that both the over-all tone reproduction curves as shown in Figure 7-23 and 7-28 and high signal-to-noise ratio can be maintained.

In addition, it is planned that each payload will be calibrated during testing, so that measured tone reproduction curves will be available for each payload. Gray scales (9-steps) were included in the pre-exposed test targets for this purpose. During operation, continuous calibration of the read-out equipment will be possible by using gray scales pre-exposed on the margin of the vehicle film.

The following table can be used as a reference for relating Type SO-243 Film read-out density to the reassembled record density:

| Gray Step No. | SO-243 R/O Density Range | Reassembled Record Density Range |
|---|---|---|
| 1 | 0.21 - 0.29 | Clipped by GRE |
| 2 | 0.26 - 0.34 | 1.89 - 2.11 (clipped if R/O density below 0.30) |
| 3 | 0.34 - 0.42 | 1.64 - 1.82 |
| 4 | 0.45 - 0.57 | 1.33 - 1.49 |
| 5 | 0.61 - 0.73 | 0.99 - 1.13 |
| 6 | 0.82 - 0.94 | 0.66 - 0.80 |
| 7 | 1.05 - 1.21 | 0.50 - 0.60 |
| 8 | 1.32 - 1.48 | 0.42 - 0.50 (may be clipped) |
| 9 | 1.40 - 1.56 | Clipped by GRE |

As can be seen in Figures 7-23 and 7-28, the predicted density range in the reassembled record falls well within the desired range.

# SECTION 8
# NUMERICAL SUMMARY

The numerical values associated with the PS are summarized in this section. Minor changes in these values may occur as the result of changes in operating conditions and as a result of PS-to-PS variations.

## 8.1 NOMINAL MISSION PARAMETERS

| | | |
|---|---|---|
| a. | Area of interest | Lunar Surface (46 KM Nominal Perilune Orbit)<br>± 10° Latitude<br>± 60° Longitude |
| b. | Primary mission orbits | Apolune: 1850 KM Nominal<br>Perilune: Orbit A - 46 KM Nominal<br>Orbit B - 200 KM Nominal |
| c. | Eccentricity | Orbit A - 0.33582<br>Orbit B - 0.29859 |
| d. | Vehicle velocity at Perilune | Orbit A - 1.916 KM/sec<br>Orbit B - 1.812 KM/sec |
| e. | Nominal illumination of lunar surface (solar constant) | 12,500 foot-candles |
| f. | Maximum brightness of lunar surface (albedo = 0.18) | 2250 foot-lamberts |
| g. | Albedo range | 0.06 to 0.18 |
| h. | Orbital period | Orbit A - 208.0 Minutes<br>Orbit B - 217.3 Minutes |
| i. | Orbital inclination | Primary Mission Orbits<br>Orbit A - 15° Nominal<br>Orbit B - 15° Nominal |

j. Inclination of major axis of orbits to moon terminator — 27.5° Nominal

k. Lunar gravitational constant — 4902.7779 $KM^3/sec^2$

l. Mean lunar radius — 1738.3 KM

## 8.2 PHOTO SUBSYSTEM OUTPUT

a. Form — Reconstructed photograph on film via video link

| | | High Resolution Lens | Low Resolution Lens |
|---|---|---|---|
| b. | Coverage photographed area (non-redundant (194 frames) (20 frames/orbit maximum) | Orbit A - 11,000 $KM^2$ (8.8% forward overlap) (9.36% side overlap) | Orbit A - 95,000 $KM^2$ (52.2% forward overlap) (20.03% side overlap) |
| | | Orbit B - 68,000 $KM^2$ (8.8% forward overlap) (78.66% side overlap) | Orbit B - 603,000 $KM^2$ (52.2% forward overlap) (81.29% side overlap) |
| | Scale in PS | Orbit A - 1:75,450<br>Orbit B - 1:328,200 | Orbit A - 1:575,000<br>Orbit B - 1:2,500,000 |
| | Ground scene dimension per frame | Orbit A - 16.52 KM X 4.15 KM<br>Orbit B - 71.95 KM X 17.95 KM | Orbit A - 37.46 KM X 31.67 KM<br>Orbit B - 164.16 KM X 138.49 KM |
| c. | Surface resolution at 76 lines/mm on spacecraft film | Orbit A - 1 meter<br>Orbit B - 4.35 meters | Orbit A - 7.6 meters<br>Orbit B - 33.20 meters |
| | at 100 lines/mm on spacecraft film | Orbit A - 0.75 meter<br>Orbit B - 3.76 meters | Orbit A - 5.75 meters<br>Orbit B - 24.9 meters |

## 8.3 SPACECRAFT DATA - NOMINAL

a. Moment of inertia — I - 68 slug-ft$^2$ at burn out; I - 78 slug-ft$^2$ max

b. S/C center-of-gravity in PS coordinate system — X = -1.8 inch, Y = 0, Z = -8.7 inches

## 8.4 PS DATA*

a. Over-all size — 26 - Y axis, 22 - X axis, 32 - Z axis (Dimensions are in inches)

b. Over-all weight — 138.36 lbs.

c. PS center of Gravity in PS coordinate system*

| | Prelaunch | Post-Photo Pre-Final Readout | Post Readout |
|---|---|---|---|
| X | +1.49 ± 0.10 inches | +1.66 ± 0.10 inches | +1.53 ± 0.10 inches |
| Y | -0.057 ± 0.10 | -0.02 ± 0.10 | -0.06 ± 0.10 |
| Z | +1.89 ± 0.10 | +2.00 ± 0.10 | +2.13 ± 0.10 |

d. PS moments and products of inertia*

| | | |
|---|---|---|
| $I_{xx}$ | 62 | in lb sec$^2$ |
| $I_{yy}$ | 57 | in lb sec$^2$ |
| $I_{zz}$ | 43 | in lb sec$^2$ |
| $P_{xy}$ | 11.5 | in lb sec$^2$ |
| $P_{yz}$ | -4.3 | in lb sec$^2$ |
| $P_{xz}$ | -68 | in lb sec$^2$ |

*Will vary slightly from PS-to-PS. See the appropriate data package.

| | |
|---|---|
| e. Principal components | Camera<br>Processor/Dryer<br>Readout Group<br>Film Handling Mechanism<br>V/H Sensor<br>CCP |
| f. Construction | Pressure vessel for 1-2 psi differential |
| g. Environment | |
| Temperature of pressure shell | 60° ± 10°F |
| Pressure within pressure shell | 1.0 - 1.9 psi |
| Pressure shell leak rate | less than 0.03 SCF/day |

## 8.5 CAMERA

| | |
|---|---|
| a. Type | Dual Frame |
| b. Lenses | |
| (1) High resolution | Pacific Optical<br>24-inch* (610 mm) f/5.6<br>film format 2.165 inches x 8.622 inches |
| (2) Moderate resolution | Schneider Xenotar<br>3.15 inch* (80 mm) f/5.6<br>film format 2.165 inches x 2.560 inches |
| c. Shutters | |
| (1) High resolution lens | Focal Plane |
| (2) Moderate resolution Lens | Between the lens - Prontor I (Modified) |
| d. Exposure Times* | 1/25, 1/50, 1/100 second by RTC command |

*Will vary slightly from PS-to-PS. See the appropriate data package.

| | |
|---|---|
| e. Image motion compensation | |
| (1) Method | Translation of Film Plane |
| (2) Control | By V/H sensor |
| (3) Nominal IMC velocity | |
| Orbit A (46 km) | a. High Resolution Lens 25.37 mm/sec<br>b. Moderate Resolution Lens 3.36 mm/sec |
| Orbit B (200 km) | a. High Resolution Lens 5.52 mm/sec<br>b. Moderate Resolution Lens 0.58 mm/sec |
| f. Scene width (both lenses) | 2.165 ± 0.001 inches |
| g. Edge data width (pre-exposed) | $0.0375^{+0.0000}_{-0.0020}$ inches |
| h. Edge data control | Gray Scales, Resolution charts, Scanner Spot reference, Re-assembly Track-linearity, Focus lines, Frame number. |
| i. Photograph cycle time at perilune | Orbit A - High Framing Rate 1.98 sec per frame<br>Low Framing Rate 7.91 sec per frame<br>Orbit B - High Framing Rate 9.09 sec per frame<br>Low Framing Rate 36.37 sec per frame |
| j. Operating temperature | 70 ± 5°F |

## 8.6 FILM PROCESSING

| | |
|---|---|
| a. Method | Lamination with Kodak Bimat Film (Estar Base), Type SO-111 presoaked with Kodak Bimat Imbibant PS-485K. |

| | | |
|---|---|---|
| b. | Processing speed | 2.4 ± 0.1 in/min |
| c. | Processing time | 3.22 minutes |
| d. | Processing temperature | 85° ± 2.5°F |
| e. | Drying temperature | 95° ± 3°F (at 1 psia) |
| f. | Drying time | 11.7 minutes |
| g. | Drying speed | 2.4 ± 0.1 in/min |
| h. | Bimat film storage temperature | 60°F ± 10°F |
| i. | Weight of payload film + leader | 2.30 lbs (260 ft) |
| j. | Weight of Bimat film | 2.50 lbs (240 ft) |
| k. | Relative humidity in pressure vessel | 50 ± 20% |
| l. | Bimat spool capacities | 260 ft |

## 8.7 PHOTO READ-OUT

| | | |
|---|---|---|
| a. | Rate of readout | 22.02 ± 0.01 sec/per framelet |
| b. | Framelet size (including ± 0.0025 over-scan) | 0.105 inch x 2.269 inch |
| c. | Maximum readout rate | |
| | (1) Before Bimat cut | 1 Frame/Orbit; not more than 4 consecutive orbits |
| | (2) After Bimat cut | 2.0 Frames/Orbit (may be increased as a result of test program) |

d. OMS lens

| | |
|---|---|
| (1) Designation | M-176A |
| (2) Aperture | f/2.4 $^{+0.1}_{-0}$ |
| (3) Focal length | 13.32 mm ± 1% |
| (4) Angular field | 7.70 degrees - half angle |
| (5) Scanning dimensions at film | |
| (a) Scan line interval | 286 lines/mm |
| (b) Framelet width | 0.105 inches (2.67 mm) |
| (c) Film advance per framelet | 0.100 inches (2.54 mm) ± 0.001 inches |
| (d) Spot diameter (in film plane) | 0.0065 $^{+0.0002}_{-0.0003}$ mm |
| (e) Linear scanning distance | 2.269 ± 0.0002 inches (57.63 mm) |
| (f) Lens shuttle time | |
| (1) Linear travel time | 20.02 sec ± 0.10 |
| (2) Turnaround time | 2.0 sec ± 0.01 |
| (3) Total scan time/frame | 22.02 ± 0.11 sec |

e. Line-scan tube

| | |
|---|---|
| (1) Line Length (on anode) | 2.372 inches |
| (2) Effective spot diameter | 0.0044 inches |
| (3) Drum speed | 1000 rpm (minimum) |
| (4) Phosphor | P16 |
| (5) Anode voltage | 20 KV nominal |
| (6) Spot velocity on anode | 2036 in/sec nominal |

f. Composite video signal

| | | |
|---|---|---|
| (1) | Scan frequency | 800 cps |
| (2) | Nominal video bandwidth | 230 kc |
| (3) | Blanking pulse width | 90 µsec ± 4 |
| (4) | Sync pulse width | 25 µsec ± 2 |
| (5) | Front porch width | 23 µsec ± 5 |
| (6) | Active scan time | 1160 µsec nominal |
| (7) | Scan time between fiducial marks | 1105 µsec ± 11 |
| (8) | Video signal voltage (4 K-ohm load) | 5 ± 0.2 volts (white to black) |
| (9) | Sync pulse voltage (4 K ohm load) | -0.90 ± 0.21 volts (below black) |
| (10) | Black level | -2.1 ± 0.1 volts |
| (11) | Scan period | 1250 µsec ± 0.12 |

## 8.8 FILM HANDLING SYSTEM

a. Loopers*

| | | |
|---|---|---|
| (1) | Supply looper electrical capacity | $2^{+0}_{-1/2}$ inches |
| | Mechanical capacity | 3 1/2 ± 1/16 inches |
| | Tension | 1.5 ± 0.1 pounds |
| (2) | Camera storage looper electrical capacity | $237^{+5}_{-0}$ inches |
| | Mechanical capacity | $258^{+1\ 1/2}_{-0}$ inches |
| | Tension | $1.75^{+0.7}_{-0.5}$ pounds |
| (3) | Readout looper electrical capacity | $48^{+2}_{-0}$ inches |
| | Mechanical capacity | $55^{+1}_{-0}$ inches |

*Electrical looper capacity will very from unit-to-unit. See the appropriate data package.

| | |
|---|---|
| Looper partial - full capacity | $2.0 \begin{smallmatrix}+0.5\\-0.0\end{smallmatrix}$ inches from electrical empty |
| Tension | $2.00 \begin{smallmatrix}+0.5\\-0.5\end{smallmatrix}$ pounds |
| (4) Take-up looper electrical capacity | 2 1/2 ± 1/4 inches |
| Mechanical capacity | $3\ 1/2 \begin{smallmatrix}+1/16\\-3/16\end{smallmatrix}$ inches |
| Tension | 2.80 ± 0.25 pounds |
| b. Spools | |
| (1) Supply spool capacity | $260 \begin{smallmatrix}+20\\-0\end{smallmatrix}$ feet |
| (2) Take-up spool capacity | $260 \begin{smallmatrix}+20\\-0\end{smallmatrix}$ feet |
| c. Camera film advance Advance time per frame pair | 1.0 ± 0.1 seconds |
| Amount of film per film advance | 11.690 ± 0.117 inches |
| d. Thread-up length | |
| (1) Loopers full | 546.5 inches |
| (2) Minimum (loopers electrically empty) | 234.8 inches |

## 8.9 V/H SENSOR

| | |
|---|---|
| a. Range of operation | 0.008 to 0.050 $sec^{-1}$ |
| b. Output rotational speed ratio | 12.1575 rps per $sec^{-1}$ |
| c. Number of tracking cycles per output shaft rotation | 2 |
| d. V/H at Orbit A perilune (46 km) | $41.6 \times 10^{-3}$ $sec^{-1}$ |
| V/H at Orbit B perilune (200 km) | $9.05 \times 10^{-3}$ $sec^{-1}$ |

f. IV Shaft - period of one revolution

| | |
|---|---|
| At Orbit A perilune | 1.977 sec |
| At Orbit B perilune | 9.091 sec |

## 8.10 PS POWER CONSUMPTION

The maximum power requirements during PS operational modes are:

| | |
|---|---|
| Solar eclipse | 22.1 watts* |
| Standby | 77.2 watts* |
| Photographic | 104.9 watts* |
| Processing | 109.4 watts* |
| Bimat cut | 86.6 watts* |
| Readout | 61.4 watts* |

## 8.11 FILM

a. Vehicle film

| | |
|---|---|
| (1) Type | Kodak Special High Definition Aerial Film, Type SO-243. Processed with Kodak Bimat Film, Type SO-111 soaked with PS-485K Imbibant |
| (2) Width | 2.754 inches (70 mm film) |
| (3) Length | $255^{+5}_{-0}$ (227 ft used for 194 photographs) |
| (4) Thickness | 0.0058 inches |
| (5) Weight | 2.20 lbs (260 ft) |
| (6) Leader | $30^{+0.5}_{-00}$ ft (Thin Base Estar preprocessed test film; total thickness of 0.0035 inch) |

*Based on supply voltage of 30.5 volts.

b. Ground reconstruction recording film

| | |
|---|---|
| (1) Type | Eastman Television Recording Film, Type SO-349 |
| (2) Width | 35 mm |

c. Reassembly film

| | |
|---|---|
| (1) Type | Kodak Aerographic Duplicating Film, (Estar Base) Type 5427 |
| (2) Width | 9.5 inch nominal |

## 8.12 INSTRUMENTATION

a. Telemetry and test points

| Identification | No. of Test Points | No. of Telemetry Points |
|---|---|---|
| Film transport | 0 | 3 |
| Camera | 2 | 5 |
| Processor | 0 | 0 |
| Bimat film status | 1 | 2 |
| Readout | 4 | 1 |
| Environmental | 1 | 13 |
| Power | 9 | 4 |
| Command | 3 | 9 |
| Total | 20 | 37 |

b. Instrumentation signal output

(1) Analog - 0-5 volts

(2) Digital

(a) $0 {}^{+1.0}_{-0.3}$ volts for negation (false) (logic "zero")

(b) $6 {}^{+1.6}_{-0.6}$ volts for affirmation (true) (logic "one")

c. Instrumentation load impedance

(1) Analog - 5 megohms

(2) Digital - 500K minimum

d. Instrumentation source impedance (analog) - less than 5K

## 8.13 GROUND RECONSTRUCTION EQUIPMENT

a. Ground reconstruction electronics

| | |
|---|---|
| (1) Input signal | Composite video signal, 6.0 + 0.4 peak-to-peak, sync negative, 72 ± 1% ohm input impedance |

b. Kinescope

| | |
|---|---|
| (1) Tube | RCA C24031 (or equivalent) |
| (a) Resolution | 230 kilocycle/sec (min) signal |
| (2) Operation mode | Line scan |
| (3) Horizontal sweep amplitude | 3.15 ± 0.5 inches peak-to-peak |
| (4) Warm-up time | 45 minutes |

c. Recording camera

| | |
|---|---|
| (1) Type | Westrex 35 mm Recording Camera (modified) |
| (2) Film drive velocity | 0.8160 ± 0.0020 inch per sec |
| (3) Film capacity | 1000 ft maximum (Standard Mitchell magazine) |
| (4) Lens | 50 mm, f/2 (M-235, EKC) |
| (5) Warm-up period | 45 minutes |